THE ARTIST'S HANDBOOK

A complete professional guide to materials and techniques

Pip Seymour

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About the Author

Pip Seymour is a painter and writer, who lives in England and Italy. He studied Fine Art at Bradford College of Art, Winchester School of Art and Brighton Polytechnic and has been a practising artist since the mid-1980s.

He teaches about the use of painting materials at a number of institutions in the United Kingdom, including the Prince's Foundation, London; Camberwell College of Art & Design, London; the Colour Museum, Bradford and Abbot Hall Art Gallery, Kendal, Cumbria.

Pip Seymour is a member of the Society of Dyers and Colourists.

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Introduction

In relation to the activity of painting, the application of technique can be a crucial factor in the complete realisation of painted images.

For many artists, the role of technique in painting is somehow missing. In recent years, the teaching of Fine Art has concentrated more on the development of ideas than on the provision of information relating to the properties of painting materials. Despite this, many artists require technical information about their materials in order to progress and develop their work.

My own students have frequently asked for more information than is possible to transmit in the teaching environment, often the type of detailed information that pertains to an individual path of development. The need to provide this has prompted me to attempt to put into book form everything I have learnt about painting materials and practice over the last fifteen or so years.

The aim of this book is to collate, in one comprehensive volume, information that would otherwise require cross-referencing from many different publications, from various time periods.

The book is intended as a resource for painters, and covers practically all the accepted paint media in some depth. In many senses, this book is a personal response to the choice and use of materials. This information has been gleaned from my own painting practice; through discussion with other artists, students, fellow tutors, paintmakers and conservation specialists.

The information included in this book is not intended to be prescriptive: some of the opinions about materials expressed here relate to my own practice, and my understanding of the working properties of the materials discussed. Nevertheless, this information has been hard won: just like any other painter, one makes mistakes along the way and one continues to make mistakes. Indeed, some of the most interesting paintings come by accident, or through experimentation with materials.

The recipes, formulas and technical advice can be considered as a starting point for any artist who is interested in developing their technique. To this end, the raw materials used in painting are discussed at length, along with some practical advice as to how best to incorporate these raw materials into paints, mediums, primers, varnishes, etc.

The importance of understanding the nature of the materials one uses in painting cannot be underestimated. Without some basic knowledge of the working properties of materials, artists may not fully develop and progress with their work.

The materials at the disposal of the modern-day artist are perhaps wider in scope than at any other time in history. However, because many of these materials are presented in ready-to-use form (e.g. tube oil colours), many artists do not know how their paints and associated materials are manufactured, and where, why and how those materials came to be used in the first place. This book attempts to provide information on just these aspects, by giving some historical background in relation to the use of a material (e.g. the date of introduction of a pigment) and suggestions on how best to use it.

At the beginning of the 21st century, we find ourselves in the strange position of having available not only modern, industrially made pigments but also a revived selection of historical colours.

For the modern artist, the choice is not just between different brands of paint, but also between hand-made paint systems and manufactured paint ranges. As a consequence, this book focuses strongly on the properties of pigments and their incorporation into a variety of different binding agents.

When an artist selects a pigment, it is often possible to use that pigment with the whole family of binding agents available. However some pigments are not stable in certain mixtures. In order to help facilitate good working practice, each pigment is identified with the appropriate binding system(s), conforming to the notion that artists should make their work with longevity in mind.

Similar information is provided in relation to the working properties of binders, resins, waxes, gums, and all the other materials commonly used in artists' paints. The correct choice of priming for example, is fundamental to the execution of both the image and longevity of the finished artwork. Wherever information is available in relation to a material, it is given in order to provide as thorough a background as possible to all of the materials used in painting.

Information on the permanence of pigments is included, with the proviso that this was accurate at the time of going to press. The supply of artists' materials, like any other material, is in constant flux: as a consequence, specifications relating to a material may change.

The historical information on pigments (and other materials) comes mainly from the Western European tradition: the same materials may be handled and prepared in different ways in some other cultures, most noticeably in Oriental painting.

Our understanding of the use of painting materials changes and develops with time. Thanks to modern conservation techniques, the composition of historical paint layers has begun to be successfully identified. With this development, some previously obsolete colours, such as smalt and lead-tin yellow have come back into the palettes of contemporary artists. Similarly, historically important paint binders, such as lime-fresco and encaustic have been revived.

For many artists, the choosing of colours remains a daunting task without some supervision. For each paint media, a selection of basic colours is suggested. These can be adopted as a starting point: there will be many others to explore. Again, the pigment section provides a link between colour and appropriate binding agent.

Modern artists' paint ranges offer the opportunity to work with pigments that have a high permanence to both light and air. Most artists' materials companies offer their own permanence ratings in their catalogues and on colour charts/tube labelling. In the pigment section, an indication of permanence according to independent authorities (Blue Wool Scale/ASTM) is provided where available.

Some artists continue to use older colours, sometimes of a less-permanent nature. The pigment section contains much relevant information about all the pigments that are currently available to the market. The choice of colours listed relates to my own travels within the last few years, through Europe and North America. The section includes all the pigments I have found listed as being available in current artists' supply catalogues and associated literature.

Similarly, other materials (oils, gums, resins, waxes, etc) are included because one can find them on the market today. While some of the techniques discussed have historical importance (e.g. egg tempera painting), all media are considered and given value. For example, the properties of acrylic paint systems are discussed at length, with the aim of giving the reader a clear overview of how best to use this relatively new medium.

In making this book as comprehensive as possible, my aim has been to provide information on each material commonly used in painting practice, from which artists can choose the appropriate materials for their own work.

My hope for this book is that it becomes a standard resource for all artists, providing a practical link between material and practice.

Pip Seymour, London. 2003

Pigments

Pigments: An Introduction

The colouring substances employed in paint manufacture are derived from many sources. In simple terms, colour can be presented in the form of pigments (composed of finely divided particles) or dyestuffs (which dissolve when introduced to water or alcohol to form coloured liquids). In most instances, dyestuffs are not used in paint manufacture, because they are a) resoluble, b) without body/solidity and c) liable to fade when exposed to the ultra-violet light rays contained within sunlight.

By contrast, pigments always have a particle structure, even when the particle size is minuscule. Consequently, pigments are easier to control when mixed with binding media and create stable pastes of colour, which can be expressed by brushing or spreading on to a surface. In addition, pigments usually have a greater resistance to fading on exposure to sunlight when compared to dyestuffs.

A simple way to check the quality of a pigment is to place a small quantity of powdered pigment (e.g. 20g) into a glass jar (100ml). Fill the jar with cold water, stir, and then leave to stand for 2-3 days. After this time, all the pigment particles (being heavier than water), will have settled at the bottom of the jar, leaving the water clear. If the pigment contains an addition of dyestuff, the water may remain coloured, even after being left to settle for many days or weeks.

The pigments used in the manufacture of the best quality of artists' colours are carefully chosen, to provide optimum results.

The ideal pigment for use in an artists' colour would be:

- Fast to light. Does not lose its brilliance when exposed to sunlight.
- Permanent to atmospheric conditions (e.g. some lead-based pigments are known to darken when exposed to sulphurous compounds in the air).
- Regular in particle size, helping to provide a uniform/stable paint paste.
- Free of impurities: some earth pigments have inclusions of "foreign" matter, which can cause difficulties in the mixing process, when preparing colours.
- Free of additives: some pigments are topped up with filler material (low tinting strength white pigments, such as blanc fix, or chalk), or admixed with other pigments.

In practice, there are some pigments in use which do not conform to this wish list, simply because they have always been used by tradition. Alizarin crimson, a synthetic organic pigment first introduced in the mid-19th century, is a good example. Despite the fact that it is known to fade when applied as a glaze (a thin, transparent layer), it has remained in artists' colour assortments because artists still demand it, even though there are a number of modern alternatives which could easily be substituted.

Similarly, many artists dislike modern synthetic iron oxides (e.g. mars red, mars yellow), because, although they have similar colour values to the traditional earth pigments, they lack character. Synthetic iron oxides are super-opaque, absolutely regular in particle size and do not tend to alter from one batch of pigment to another. By contrast, natural ochre pigments, dug from the earth, are always irregular in terms of particle size and can alter in shade from batch to batch, due to inclusions of varying amounts of chalk and silica. When prepared into paint form, such earth pigments tend to be slightly gritty in texture and may take longer to mix into an acceptable paint paste. Despite this, or perhaps because of it, artists often choose such colours, because they show character, idiosyncrasy and contrast when compared with modern, industrial products.

It is this facet in regard to the raw colouring material that makes the understanding of pigments so vital to anyone learning to paint, or involved in the practice of painting.

The character of each pigment is different. The way that each pigment is mixed with a binder to form a paint paste can be different. It is also true that as artists, we express each colour differently on to the painting support, according to the characteristic of that particular colour. For example, viridian is a bright, cold green which shows great transparency when applied as a glaze. When mixed with other colours, it loses its influence within that mixture (i.e. it has a low tinting strength). Why is this? How can we recognise this? In practice, we find such information through trial and error: by taking each colour in turn and working with it; mixing it with white to see how it behaves as a tint; applying it to white grounds and to black grounds to see how transparent it is (very transparent pigments hardly show at all when applied to black grounds).

This section aims to provide in-depth information about the characteristics of all the pigments that are commonly used in artists' materials, or that have been used in painting practice. In addition, a number of historic pigments are mentioned because in recent years they have become available to the market again, especially in dry pigment form.

Key to Pigment Information

For each pigment, a table has been created to provide as much information as is currently available. The tables are laid out in the following format:

Colour Index Name

The Society of Dyers and Colourists have assigned many colouring substances an index name and number as a means of identification. Such information is used by the paint industry to identify ingredients and is also often included on the labelling of artists' colours or associated product information. For example, lead white is known as PW 1 (Pigment White Number 1).

Colour Index Number

The Colour Index Number is a further means of identification used within the paint industry. For example, lead white is Colour Index Number CI 77597.

A complete up-dated list of all colouring matter is available from the Society of Dyers and Colourists in the form of both book and CD-Rom (see Bibliography).

Common Names

The traditional colour name (e.g. venetian red, is the common name for a natural red earth pigment with a slightly pink-violet undershade). Other commonly accepted names for the same pigment are included (e.g. ultramarine is often referred to as french ultramarine. This relates to its development in the 19th century, where it was first patented in France).

Origin

A description of the manufacturing process and/or where the raw material is sourced. An outline of the use of each pigment in painting practice citing, in some cases, specific use by individual artists.

Composition

The accepted chemical formula for a pigment. For example, lead white is basic lead carbonate ($2PbCO_3$).

Tinting Strength

The relative tinting strength of a pigment (e.g. when admixed with white).

Shade

A description of the shade (warm, cold, bluish, reddish, etc) of each pigment.

Suitability to Media

Certain pigments are not compatible with some of the binding agents used for paint making. For example, lead-based pigments do not work well in acrylic binders, because they are too heavy to remain stable in the acrylic resin dispersion binder.

Opacity/Transparency

Pigments can give either transparent or opaque paint films, depending on the particle size and structure. For each pigment, the relative transparency/opacity is indicated – a useful aid when selecting colours.

Defects

Some colours cannot be intermixed, or may change appearance on exposure to light/atmosphere. In some cases, this can be countered by selection of specific binding media (e.g. lead white is less prone to sulphurous compounds when prepared as an oil paint than when prepared in a water-based binder, because the oil film protects the pigment from exposure to the atmosphere).

Availability/Cost

The relative availability of a pigment through regular suppliers of artists' materials is mentioned and, where noteworthy, reference is made to its cost (e.g. rock-mineral based pigments tend to be quite costly, whereas modern, industrial iron oxides are inexpensive). The cost of the raw material (pigment) may have some influence on the buying price of a paint product.

Special Comments

If a pigment requires a wetting agent in order to aid dispersion into the chosen paint binder, this is indicated. The choice of correct wetting agent is vital. The following wetting agents are commonly used in the manufacture of artists' paints:

Wetting Agent for Oil Colours

Mineral (white) spirit. It is not advised to use turpentine, because this solvent takes longer to evaporate than mineral spirit. Special dispersion formulations may be available for oil colours, under brand names (e.g. "Disperse aid").

Wetting Agent for Acrylic Colours

Special synthetic wetting agents are available, usually in the form of very dilute detergent (e.g. "Orotan", "Disponil"). Check with supplier as to the most appropriate wetting agent when purchasing acrylic resins.

Wetting Agent for Watercolours/Gouache

Alcohol, or ox-gall. Ox-gall is normally sold as a dilute liquid, sometimes deodorised. Neat ox-gall may be over-strong (causing too much wetting, dispersion of paint paste) and prone to the release of bad odour. Alcohol should be 99% water-free and non-coloured. It may be wise to dilute the alcohol with a little water, prior to use.

Wetting Agent for Hand-made Soft Pastels

Alcohol, diluted with water in the ratio one part alcohol to ten parts water.

Wetting Agent for Egg Tempera

Alcohol.

Wetting Agent for Casein Binder and Animal Skin Glue Binders

Alcohol.

Where applicable, further information is provided on the special characteristics of some pigments. For example, some of those derived from minerals, such as the semi-precious stones malachite and azurite, need careful preparation. When such pigments are mixed for too long, the particle size can be altered: as the particle size reduces, so the colour becomes paler and paler. Consequently, it is normal with these two pigments to mix them with the relevant binding agent using a slightly coarser particle size than would be the case with other pigments.

Drying Rate (in Oil Paint)

Some pigments have a catalytic effect on the vegetable oils used as binders for artists' oil colours. For example, raw umber (containing manganese deposits) will cause linseed oil to dry out in perhaps a day, or even less. As a consequence, it is often employed for underpainting (the first "sketching-in" coat of paint). Such fast-drying colours can be admixed with other pigments to improve their drying rate. This fast-drying action is only seen in oil-based paint systems.

Heath & Safety Information

Some pigments can be potentially injurious to the user, especially in their dry, powdered form. All dry, powder-form pigments represent a hazard in that they can be classed as nuisance dusts. It is imperative when handling dry pigments that the user wears an appropriate dust mask, protective gloves and protective clothing. An indication is given of the relative health hazard of each pigment.

The supplier of each material may offer further information on its correct use. It is prudent to request up-to-date information on all the materials discussed, as the available information is always changing.

Pigment Types

Pigments can be derived from two distinct sources:

1. Inorganic Pigments.
2. Organic Pigments.

Inorganic Pigments

Colouring matter that is derived from compounds that were never part of living matter are considered to be inorganic pigments. Within this category there are coloured compounds that are formed as a) earth deposits, b) mineral/rock, c) treated metallic compounds and d) fused metallic compounds.

Some Examples of Inorganic Pigments

Earth Deposit	Yellow ochre. Mix of clay with silica, tinted by iron deposits which oxidise to give a coloured earth.
Earth Deposit (naturally calcined)	Pompeii red. A natural earth pigment, given a red tinge through contact with heat from volcanoes.
Earth Deposit (artificially calcined)	Burnt sienna. Natural (raw) sienna is a special type of ochre, which contains a high proportion of silica (a translucent material). Raw sienna gives a relatively transparent paint film, when applied as a glaze. When raw sienna is calcined (heated) in a closed furnace or kiln, it changes shade to give a

	fiery-red colour. This calcining process also creates a slightly more transparent effect when the resultant paint paste is applied as a glaze.
Mineral/Rock	Cinnabar. A red rock, fused from mercury with sulphur, normally within volcanoes. It may also contain other aggregates such as sandstone, quartz, etc. The rock is pulverised in a pestle and mortar, then put through a fine sieve to separate the different particle sizes in order to gain a red pigment with a regular particle size. This pulverised form of cinnabar is known as vermilion ("*the little worm*" – Old French and Latin).
Treated Metallic Compound	Lead white. When sheets of lead are exposed to vinegar, the metal corrodes to form carbonate of lead. This simple white pigment is one of the oldest manufactured inorganic pigments, dating back to antiquity.
Fused Metallic Compounds	Cobalt blue. When two metallic compounds are burnt together (fused), they can be employed to create a new material. Cobalt blue, for example, is a fusion of cobalt and aluminium oxides.

Organic Pigments

Colouring matter that is derived from living substances or substances which were once part of living things, can be ascribed as organic pigments. Within this category, pigments may be composed from a) animals, b) plants or c) synthetic treatment of plantstuff.

Animal	Bone black. A simple black pigment can be produced by calcining cattle bones, which are then pulverised to a fine grain powder.
Plant	Madder red lake. Many plant roots, fibres or leaves can be used to make colouring substances. In the case of madder red, the roots of the madder plant are warmed with water that has been treated with potash. This produces a red dyestuff, which is then fixed to a metallic substrate (e.g. rock alum, a type of salt) to form a pigment with a particle structure.
Synthetic Organic	Alizarin crimson. Crude oil is converted into petroleum products. The solvents created through this process can be developed, through modern organic chemistry, into a wide range of coloured dyes. Some of these dyes can be converted into pigment form (attached to a particle structure). These "synthetic" organic pigments provide very strong, bright colour and are now widely employed within the paint industry as colourants.

Particle Size of Pigments

Pigments are rated according to the size of the individual (molecular) particles from which they are composed. The measurements are given in microns (μ).

The relationship between particle size and the binding agent used can be a factor in the making of coherent paint films. For example, the micron size of natural earth pigments (naturally occurring oxides of iron) may vary from between 20-50 microns and the particle structure may be irregular. By contrast, synthetic iron oxides (artificial oxides of iron) may have a particle size as small as 10 microns. In addition, the regular form of such manufactured pigments can make them easier to incorporate within the chosen binding system.

The micron size is represented by the symbol µ. The term "grind size" is also sometimes used in connection with particle size.

Comparative examples of micron size in pigments (sizes vary according to manufacturer and processing of the original material):

Natural Earth Pigments	20-50µ
Synthetic Iron Oxides	10µ
Synthetic Organic Pigments	0.1-5µ
Titanium White	5-15µ
Azurite	10-120µ (larger particle size shows greater colour)
Glass Pigments	63-125µ (larger particle size shows greater colour)

The combination of larger particle size pigments with smaller particle size pigments may lead to a loss of colour resonance in the resultant paint film. Rather than intermixing pigments with widely differing particle sizes, it may be better to overlay one colour on top of another to gain the optimum effect.

Artists' Pigments

The following index of pigments includes information on both historic and modern colours. Wherever possible permanence information is included. However, the reader should bear in mind that such information is always in flux and liable to revision over time. Where a pigment has been mentioned, its inclusion indicates its use in the fine arts, it does not necessarily confirm permanence or recommend use in permanent works of art.

Pigments Classification

When purchasing artists' colours, the colour name given on the product label may or may not relate to the pigment(s) used in its manufacture. It is important that artists understand the composition of the paints they use, to ensure a full understanding of a) the working properties of the paint chosen, b) the composition of the raw materials of that paint and c) the potential toxicity of the paint. The artists' materials industry often assigns names to paints that do not reflect their chemical composition. For example, sap green is often a combination of two or more pigments. Within published information (e.g. colour charts), the manufacturer may indicate the pigment composition of the paint. Increasingly, many companies show the pigment composition on tube or can labelling. However, this approach has not been adopted by all manufacturers: as a consequence, artists may need to do some research before selecting their materials. Where the manufacturer does indicate the pigment composition of their paints, identification is made by use of the relevant Colour Index Name and/or Number.

The Colour Index (C.I.) is the internationally recognised system for the identification of pigments and dyes. It is published jointly by the Society of Dyers and Colourists in the United Kingdom and the Association of Textile Chemists and Colorists in the United States. The Colour Index includes technical information and classification of all coloured materials, including pigments and dyes that may be found in artists' materials.

The complete Colour Index identification comprises two separate items:

a) The Colour Index Name

An example of a Colour Index Name would be "C.I. Pigment Violet 23".

The Colour Index Name comprises three different parts:

1. Use. What the colourant is used for (e.g. "Pigment", or dye class such as "Acid" or "Reactive").
2. Colour. Pigments are classified into ten colour groups, which are abbreviated as follows:

PB pigment blue, PBk pigment black, PBr pigment brown, PG pigment green, PM pigment metal, PO pigment orange, PR pigment red, PV pigment violet, PW pigment white, PY pigment yellow. NR = natural red, NY = natural yellow, etc (for colours based on plant or other organic source).

3. A Number. This number was assigned sequentially as the substance was added to the Index and has no chemical or constitutional significance.

b) The Constitution Number

C.I. Constitution Numbers are assigned by chemical class and run from 10000 to 77999. From this number, the exact formula and structure of most dyes and pigments can be found. While this information may not be required by most artists, it may assist identification of colours. At the very least, an understanding of these classifications allows artists to recognise what pigments may have been used in the paints they choose.

The full Colour Index Name and Constitution Number for a pigment commonly found in artists' materials, alizarin crimson, is:

Colour Index Name	Constitution Number	Common Name
C.I. PR 83	C.I. 58000	alizarin crimson

The American Society for Testing and Materials (ASTM) is often quoted by manufacturers and in technical literature with regard to artists' pigments. Their ratings refer to the performance of selected pigments when ground in a variety of vehicles, for example oil, gum arabic (watercolour), acrylic. ASTM ratings relate to pigment mixed with a binder (e.g. linseed oil) rather than proprietary brands of paint. Manufactured colours may contain the pigments listed on the tube or in technical information but can also include other undisclosed materials, which could in theory reduce permanence.

ASTM Lightfastness Ratings for oil paints have been based on testing done of the chosen pigment(s), let down with titanium white to a pastel-like tint at approximately 40% reflectance.

The pigments mentioned may fall into the following categories (in relation to oil colours):

ASTM I	Excellent lightfastness
ASTM II	Very good lightfastness
ASTM III	Not satisfactory (may be satisfactory when applied full strength)

Note: ASTM ratings are continually updated, any information supplied in this text may be subject to change.

Permanence of Artists' Pigments

The Blue Wool Scale

In the textiles industry, dyed cloth is measured for fastness against light according to the Blue Wool Scale. Samples of wool are dyed with eight different grades of blue dye and exposed to sunlight for a set period (e.g. twelve months, south facing Florida sunlight). The eight separate dyes show fading to different degrees: the dye with the strongest resistance to light is graded no.8 (no change after 12 months exposure), while the dye that fades the most is graded no.1. (complete or virtually complete fading after 12 months).

Other colours (both dyes and pigments) can be exposed to sunlight and measured against this scale. With regard to artists' pigments, colours that are graded 7-8 on the blue wool scale may be considered permanent (being more or less equivalent to pigments accorded the rating ASTM I, ASTM II under the ASTM rating system). Many plant-based colours, along with the earlier varieties of synthetic organic pigments may fall below this benchmark. For example, pigments that measure 6 or lower on the blue wool scale, may perform less well when exposed to strong sunlight, or when strongly mixed with white pigments.

The information supplied by manufacturers of artists' materials and by suppliers or manufacturers of dry pigments is assumed to be correct and diligently researched. However, "home" testing of batches of paint or dry pigment may become appropriate for specific processes. For example, a number of publications have been produced in recent years that attempt to test and evaluate the performance of proprietary brands of watercolour paint. Such evaluations often seem highly subjective, but it may be a useful exercise for artists to make their own, similar tests. Such tests can provide a useful record of, for example, the way a particular paint brushes out, or perhaps the degree of granulation observed when pigment is simply mixed with gum arabic and applied to paper as a wash. A register of paint-out samples would be a useful resource for any professional artist's studio, showing paint-outs of favourite colours and perhaps admixtures between different colours. It may also be useful to expose such paint-outs to south-facing light for a period of weeks or months, to ascertain any change in terms of fading.

For such tests, the chosen paint should be applied on to a support which is the same as that normally used for painting. For oil colours, it could be an off-cut of primed canvas, or perhaps a series of primed panels. For watercolour, a suitable paper is selected. For each paint sample, the colour needs to be applied at full strength; admixed with 10% white (admixture with perhaps more than one variety of white could be considered); admixed with white in the ratio one part colour, to nine parts white; applied diluted (as a wash in watercolour); applied combined with a chosen paint medium (e.g. in oil paint, co-mixed with a 10% addition of stand oil-dammar medium). The finished paint samples are left exposed to sunlight (preferably in a south-facing window). One half of each sample can be covered up, so that it is preserved and thus acts as a "standard" against which the exposed sample can be compared. After one month, the paint sample is inspected for any changes, then re-positioned for another month, and so on. After a period of perhaps six months, any significant changes are noted and recorded for future reference. Although this procedure may seem lengthy and pedantic, it may help individual artists to recognise subtle differences of quality between one paint brand and another. In the case of dry pigments, to make a colour sample, the chosen pigment is milled into a specific binder. For example, a simple gum arabic solution can be used to make basic watercolours. This is especially useful when selecting pigments for watercolour painting, where qualities such as the staining or granulation properties of a pigment are better understood.

Staining Pigments

Some small/fine particle size pigments, such as the synthetic organic pigments and also prussian blue, tend to give a staining effect when used in water-based techniques. This is partially due to the very high tinting strength of such pigments, but is also connected to their fine particle size. These staining colours tend to be difficult to wash out of brush hairs, especially soft sable hair brushes. They may also cause running or bleeding when applied to the painting surface (e.g. painting on paper in watercolour technique), when one wet colour contacts with another.

An addition of gum water (gum arabic solution) with such colours may help to give more control in terms of application (the colour is slower to disperse). In some gouache paint ranges, colours may be based on dyes rather than pigments, which will have a strong staining effect, or rather, bleeding – where colour is easily redissolved and reactivated on the surface when re-wetted.

Granulation (in Watercolour)

The particle structure of a pigment may cause the applied paint to show an effect referred to as "granulation", where the particles partially settle out in the paint mixture, to give a granular effect. This granulation of applied colour can be aesthetically pleasing, especially in the context of watercolour painting, where the grainy particles settle out in the pits/grain of the paper. Examples of these granulation pigments include cobalt blue, cobalt violet, cerulean blue, manganese blue, cobalt green, natural earths, natural madder, stil di grain, natural indigo, viridian, ultramarine violet. Alongside these colours, most of the mineral-based pigments show granulation due to their crystalline structure. The large particle size of such pigments may mean that they require greater binding strength than finer particle sized pigments.

Pigment Tables

WHITE PIGMENTS

LEAD WHITE PW 1

Colour Index Number	77597
ASTM/BWS Rating	ASTM I
Common Names	Kremnitz white, krems white, cremnitz white, nottingham white, london white, genoa white, silver white, ceruse white, snowflake, or flake white. The term flake white is often used in tube oil paint to describe lead white admixed with zinc white. It is common for lead white oil colours also to include additions of blanc fix (barium sulphate), which is incorporated to improve the paint consistency.
Composition and Origin	$2PbCO_3.Pb(OH)^2$. Artificial mineral pigment. Basic lead carbonate. Used since antiquity. Krems is a town in Austria, where lead white pigment was produced.
Tinting Strength	Good reducing power when mixed with other colours.
Shade	Pure white, not over bright. A warmish white as oil colour.
Opacity	Fairly good – titanium white has greater hiding (covering) power.
Suitability to Media	Not suitable for use in water-based media. Lead white is a heavy pigment, which settles out in water-based media. The pigment is more prone to darkening upon exposure to sulphurous compounds in the environment, when used in water-based techniques. In oil paint and also when carefully bound in egg yolk for tempera, lead white performs well.
Drying Rate (in oil)	Fast.
Defects	In oil, lead white yellows with age, especially if kept in the dark during drying. Can blacken on exposure to (sulphur) polluted atmospheres, although this tendency is reduced when the pigment is locked in an oil binder.

Availability/Cost	Withdrawn from use in most industrial paints in Europe and the US. Current EU legislation has made it more costly and prohibitive for artists' colour-makers to produce lead white as an oil paint. As a consequence, prepared white lead oil colour has become expensive. Similarly, the dry pigment is now more expensive and more difficult to purchase. Demand from artists for this pigment is still high. The availability of lead white is limited by current UK regulations. It is available for the restoration of works of art and buildings upon application to the relevant authority. In the UK, this has been The Council for Museums, Archives and Libraries, who inherited this responsibility from the Museums and Galleries Commission. This situation is apparently due to change, however, and DEFRA (Department of Environment, Fisheries and Rural Affairs) can advise as to the appropriate authority henceforth.
Comments	As an oil colour, lead white can be prepared to provide a rich, buttery texture, ideal for mixing down with other colours. Add to other colours to speed drying in underpainting. Most flexible of all whites, with a smooth, pasty consistency, often preferred for admixing and modifying consistency of other colours.
Special Note	Lead sulphate (PW 2/C.I. 77633) is sublimed lead carbonate and not permanent for works of art – was formerly used in industrial paints.
Health & Safety Information	Toxic, contains lead. Wear gloves and dust mask when handling dry pigment. Wash hands thoroughly after using pigment or paint. Lead can be ingested through the skin – wear a barrier cream, applied to hands and forearms to ease cleaning and prevent pigment/paint from resting in contact with skin.

ZINC WHITE PW 4

Colour Index Number	77947
ASTM/BWS Rating	ASTM I
Common Names	Zinc oxide, chinese white (originally a special grade used to make body colour for watercolour painting), permanent white (not to be confused with blanc fix, which is also sometimes afforded this name).
Composition and Origin	ZnO. An artificial mineral pigment, pure zinc oxide. Developed from 1746 onwards, introduced to artists in the 1830s (by Winsor & Newton: chinese white, as a watercolour paint).
Tinting Strength	Good.
Shade	Cold, bluish white.
Opacity	Semi-opaque, admix with other colours to gain pastel shades.
Suitability to Media	Stable in oil, watercolour, gouache, tempera, but not advised for outdoor mural painting using acrylic, where the paint surface can chalk.
Drying Rate (in oil)	Very slow.
Defects	Forms brittle paint films in oil, especially when applied thickly.
Availability/Cost	Widely used.
Comments	Thick passages of paint may form hard, brittle films, leading to a danger of cracking.
Special Note	Zinc sulphate (PW 7/C.I. 77975) is formed when zinc oxide is exposed to hydrogen sulphide. Although zinc sulphate is a similar white colour to zinc oxide, it is rarely used in the preparation of artists' colours, but finds use in industrial products. It is also used in the manufacture of lithopone, where it is co-precipitated with barium sulphate. Zinc sulphate is not stable in acidic mixtures. Exposure to heat causes release of toxic hydrogen sulphide gas.

	with barium sulphate. Zinc sulphate is not stable in acidic mixtures. Exposure to heat causes release of toxic hydrogen sulphide gas.
Health & Safety Information	–

LITHOPONE PW 5

Colour Index Number	77115
ASTM/BWS Rating	Not tested.
Common Names	Lithopone silver, ponolith, carlton white, griffith's patent zinc white, jersey lily white, orr's zinc white.
Composition and Origin	$BaSO_4 + ZnS$. An artificial mineral pigment. First produced in England in the 1870s. Early lithopones had a tendency to darken when mixed with oil. The modern pigment (dating from 1926) is stable. A co-precipitate of zinc sulphide and barium sulphate.
Tinting Strength	Stronger than zinc white, with more hiding power due to better opacity.
Shade	Similar to zinc white, a bright, coldish white.
Opacity	Semi-opaque.
Suitability to Media	Oil, watercolour, gouache, tempera – although in oil it shows a certain yellow-greenness.
Drying Rate (in oil)	Very slow.
Defects	–
Availability/Cost	Inexpensive, sometimes used to bulk out other white oil paints.
Comments	–
Special Note	–
Health & Safety Information	–

TITANIUM WHITE PW 6

Colour Index Number	77891
ASTM/BWS Rating	ASTM I
Common Names	Titanox, titanium dioxide.
Composition and Origin	TiO_2. An artificial mineral pigment, Titanium dioxide is derived from ilmenite, black titanium ore. Introduced in the 1920s.
Tinting Strength	High.
Shade	Very bright pure white.
Opacity	Very opaque.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Slow. Hand-ground oil colour can take months to dry out.
Defects	Dries to a brittle film (when ground in oil). For this reason, it is not recommended for oil priming, or for thick passages of oil painting.
Availability/Cost	Inexpensive, widely used.
Comments	An inert, non-toxic pigment with the highest tinting strength of all whites and very high refractive power.
Special Note	–
Health & Safety Information	–

A Note on Pearlescent Pigments

In Japanese painting, iridescent or nacreous pigments are traditionally produced by grinding the inside of mother of pearl sea shells. This technique is still in use and Japanese art materials catalogues detail various iridescent white and pearl pigments, which are mixed with a skin glue binder in the traditional Japanese painting technique on paper. Mica, called muscovite, or muscovy glass, (hydrous potassium aluminium silicate) $H_2K\ Al_3\ (SiO_4)_3$, is a type of natural quartz, which occurs in the form of compressed thin sheets or plates that divide easily.

Mica has been used as a pigment in painting and the decorative arts. When ground into a fine powder, it acts like the Japanese ground-shell pigments, giving a slight iridescent effect. Mica is available in a variety of grades, from fine powder to sequin-size platelets. They retain their lustre best when mixed with water-based binders, especially acrylic dispersion, but also with animal glue (distemper), or gum arabic.

Mica is used as the substrate for the modern pearlescent pigments. In a costly process, the fine mica plates are coated with metal oxides. The pearlescent pigments are extremely lightfast and stable in all the usual paint binders: oil, acrylic, gum arabic, casein, lime, etc. The pearlescent pigments can be divided into three distinct groupings: Pearlescent, Iridescent and Interference.

Pearlescent types

Fine particles of mica are coated with a very thin layer of titanium white pigment (titanium dioxide, TiO_2), to produce pearlescent and silver, or rather silver-white shades. These are generally referred to as pearlescent pigments. Examples of these are the Ekaton types. They have a metallic surface sheen and brush out to a transparent glaze when prepared with medium (e.g. acrylic polymer dispersion).

Iridescent types

Iridescent pigments (for example, Colibri types) are very similar, in that they are derived from mica, which is coated with iron oxide and titanium white, or just iron oxide, to provide a range of yellow gold, orange gold and copper shades. However, they are less transparent when compared with pearlescent pigments and give a very good approximation to shades of real gold, copper and bronze. These iridescent gold, copper and bronze shades can be mixed from the dry pigment to imitate gilding effects, or in many cases, bought ready-dispersed into a binding medium.

These shades are already available in the form of acrylic and oil paint. The iridescent pigments can be mixed with animal glue binder to replicate fine water gilding effects but are perhaps closest to gold, or shell gold, when mixed into an acrylic polymer dispersion.

By contrast to similar shades available as bronze powder, the iridescent pigments show a greater subtlety with a softer finish, are stable to light and do not tarnish or oxidise.

Interference types

Interference pigments (for example, Chroma types) differ from the pearlescent and iridescent types in that the combination of refraction and reflection of light upon the titanium white coatings produces an interference effect, rather like the rainbow colours visible when looking at a thin film of oil upon the surface of water. With interference pigments, mica is coated with titanium white to a specific thickness, which allows only a narrow band of light to reflect. As a result, the eye sees just one colour of the spectrum, yellow for example. The pigment is structured so that it edits out other colours in the spectrum, which are then not seen by the eye. The resultant interference colour is best seen when the painted surface is tilted, or viewed at an angle. The colour is also more visible when painted out against a dark ground.

By contrast, when looking at pearlescent pigment types, the only colour seen is a lustrous white, or silver-white. This is because the coating of titanium white is very thin and light wavelengths are reflected as white only.

IRIDESCENT WHITE (MICA/PEARL LUSTRE)
PW 20 or PW 26 (natural mica) +PW 6 (titanium white)

Colour Index Number	77019, 77718 + 77891
ASTM/BWS Rating	Not tested.
Common Names	Pearlescent white, mica white, glimmer white.
Composition and Origin	–
Tinting Strength	When mixed with transparent pigments, the resulting colour takes on a pearlescent appearance.
Shade	Bright, pearl white.
Opacity	Translucent.
Suitability to Media	Stable in all media. In oil, the colour of the oil used may show strongly. Tends to make poor paint pastes when combined with drying vegetable oils such as poppy oil or linseed oil. Better suited to combination with alkyd resin.
Drying Rate (in oil)	Normally presented in oil colour ranges with fast-drying alkyd resin as binder.
Defects	Difficult to make into a paste without additions of wax paste. Best used as required, into glaze mediums, etc.
Availability/Cost	Expensive but intense, now available in some paint ranges and as dry pigment.
Comments	–
Special Note	–
Health & Safety Information	–

BLANC FIX PW 21 (artificially prepared), PW 22 (natural mineral barytes, heavy spar)

Colour Index Number	77120
ASTM/BWS Rating	Not tested.
Common Names	French: blanc fix; English: permanent white, constant white, barytes, heavy spar.
Composition and Origin	Barium sulphate, $Ba(SO_4)$. Occurs naturally, but can also be manufactured by precipitation of barium chloride with sulphuric acid. The manufactured form was introduced by Kuhlmann (Lille, France) in 1830.
Tinting Strength	Poor. Blanc fix has little tinting strength.
Shade	When mixed with cold water only, blanc fix appears as a perfect snow white, having a high reflectance in light. However, when mixed into any binding agent, it takes on a dull white appearance, especially so with oil binders.
Opacity	Has some opacity: when admixed with other opaque pigments, it can be used to emphasise or enhance opacity. In water-based systems it retains an opaque effect. When used as an additive in oil colours, blanc fix will enhance opacity when added in quantity, but when used sparingly, as an addition to coloured glazes, it enhances the transparency of such glazes.
Suitability to Media	Stable to all media, most often used as a filler material in oil paints and opacifier in gouache paints. When used in water-based paints, blanc fix shows as a brightish white, especially so with binders that remain water clear (e.g. klucel).
Drying Rate (in oil)	Slow.
Defects	If prepared alone as an oil colour, blanc fix would show a great tendency towards yellowing, due to weak tinting strength.

Availability/Cost	Inexpensive and widely used as an additive in artists' paints.
Comments	Blanc fix is primarily used as a filler/extender in paint systems. When added to pigments milled in linseed oil, blanc fix provides opacity but also adds bulk and weight to the paint mixture. This weight can prove to be deceptive when used in larger quantities to extend paints: the resultant tube of paint may be heavy in weight and thus seemingly appears to indicate a high pigment load. However, the inclusion of excess blanc fix will render the paint mixture rather stodgy and make the colour value somewhat dull. It is best used in small amounts to improve the consistency and regulate the opacity of the pigments with which it is mixed. In gouache paints, blanc fix may be used alone as an alternative to white. It is also commonly used in gouache paints to achieve a regular opacity across a range of colours, giving a paint paste that has body and will dry to leave a matt paint film.
Special Note	–
Health & Safety Information	Contains barium.

ALUMINIUM HYDRATE PW 24

Colour Index Number	77002
ASTM/BWS Rating	Not tested.
Common Names	Alumina hydrate, aluminium hydroxide.
Composition and Origin	$Al(OH)_3$. A metallic soap, aluminium hydrate is manufactured by mixing soda ash or potash with a solution of aluminium sulphate.
Tinting Strength	Very low, almost negligible. It is often used as a transparent extender for paint systems, notably oil colours.
Shade	Soft, bright white as dry powder. When mixed with any binder it takes on the coloration/hue of that binder. When milled with linseed oil, it creates a dull yellow-orange paste, which if applied as a paint dries to show intense yellowing/darkening.
Opacity	Has little or no hiding power when used in any binder, but especially so in oil.
Suitability to Media	Inert, can be used as a filler/extender in any paint system but most commonly with oil colours. Aluminium hydrate quickly forms a pleasant buttery paste when mixed with linseed oil. It is often added to oil colours to improve consistency. However, overuse (e.g. more than 5-10%) will leave the resultant paint unworkable, smeary in consistency. The inclusion of small amounts of aluminium hydrate in oil paints may help to break up light as it hits the paint surface, so enhancing colour resonance. Overuse will cause the paint film to become dull and lacking in luminosity.
Drying Rate (in oil)	Slow. When added to oil colours, aluminium hydrate will act to retard drying times.
Defects	When overused as an extender/filler, it encourages yellowing/darkening of the paint film. Cheaper artists' oil colours may contain larger quantities, and as a consequence may show excessive yellowing upon drying. Overuse of aluminium hydrate makes the paint paste unworkable and matts the dried paint film. Due to its very high oil absorption rate, aluminium hydrate,

	when added in quantity will encourage wrinkling or shrivelling of the drying oil paint film. In good-quality oil colours it is added sparingly, no more than 5-10% of the whole. This is especially important when adding to transparent pigments with a high oil absorption rate. Overuse of this filler in such circumstances will increase the likelihood of yellowing and may weaken the structure of the paint film.
Availability/Cost	Widely used in all artists' oil colours, but its use is governed by the quality of the paint. Ideally it is only added in small quantities.
Comments	Avoid paint mediums based on aluminium hydrate milled into linseed oil: their use will encourage darkening of the overall paint film. When hand-making oil colours, it is useful to add a small amount of aluminium hydrate (5-10%): this not only helps to stabilise consistency but will also help to prevent separation of oil from pigment when filling the paint paste into empty metal tubes.
Special Note	–
Health & Safety Information	–

YELLOW PIGMENTS

HANSA YELLOW **(types)**
RN = PY 65 - $C_{18}H_{18}N4O_6$
GX = PY 73 - $C_{17}H_{15}ClN_4O_5$
5GX = PY 74 - $C_{18}H_{18}N_4O_6$
10G = PY 3 - $C_{16}H_{12}Cl_2N_4O_4$
G = PY 1 - $C_{17}H_{16}N_4O_4$

Colour Index Number	PY 65/11740, PY 73/11738, PY 74/11741, PY 3/11710, PY 1/11680
ASTM/BWS Rating	ASTM I (except PY 3, PY 1 = ASTM II)
Common Names	Brilliant yellow, hansa yellow light, hansa yellow dark, arylide yellow, monoazo yellow, azo yellow.
Composition and Origin	Synthetic organic pigment. Originally dates from early 1900s, although the modern equivalents have been improved. These pigments are often adulterated in cheaper paint ranges by the addition of extenders. The high tinting strength allows for a greater amount of extender to be incorporated without losing colour strength. However, such additions tend to cause problems in terms of stability of consistency and loss of transparency. In oil, the slow drying rate makes hansa yellow unsuitable for any technique that involves a degree of impasto, as the paint film may wrinkle upon drying.
Tinting Strength	Good.
Shade	Bright yellow, cool to warm shades, from light to dark.
Opacity	Tends towards transparency.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Slow.
Defects	When too much extender is added, hansa yellow loses its tendency towards transparency.

Availability/Cost	Fairly inexpensive and widely used, especially in cheap paints to imitate expensive cadmiums.
Comments	New types have improved lightfastness.
Special Note	Requires wetting agent. Hansa yellows tend to show little or no yellowing when ground in oil.
Health & Safety Information	–

BARIUM LEMON YELLOW PY 31

Colour Index Number	77103
ASTM/BWS Rating	Not tested.
Common Names	Lemon yellow, barium yellow, yellow ultramarine, permanent yellow.
Composition and Origin	An artificial mineral pigment. Barium chromate, ($BaCrO_4$). Discovered by Vauquelin, 1809. Used in wider industry as ingredient in anti-corrosive paints.
Tinting Strength	Weak.
Shade	Dull, pale, yellow.
Opacity	Slightly transparent as glaze.
Suitability to Media	Stable in all media, but liable to turn greenish in oil.
Drying Rate (in oil)	Medium.
Defects	Upon ageing, becomes slightly greenish in oil paint.
Availability/Cost	Hard to find in manufactured ranges. Usually replaced with non-toxic nickel titanium yellow. The pigment is available from specialist pigment suppliers.
Comments	–
Special Note	–
Health & Safety Information	Toxic, barium chromate.

CHROME YELLOW PY 34

Colour Index Number	77600, 77603
ASTM/BWS Rating	Not tested.
Common Names	Primrose yellow.
Composition and Origin	A group of artificial mineral pigments. Lead chromate, $PbCrO_4$. Developed by the French chemist, Nicholas Louis Vauquelin (1763-1829), after studying the properties of a Russian mineral called chrocoite, which could be processed to give yellow, green and red precipitates. The discovery of French sources of chrocoite led to the industrial production of chrome-based pigments, both in France and England. Found in paintings from early 1800s. Chrome yellow was formerly used widely in industry and artists' colours. Due to its relative toxicity, EU directives have reduced the availability of the chrome pigments. Chrome yellows can darken on exposure and with age. In recent years, chrome yellows have been developed in which the particles have been silica encapsulated, so preventing darkening upon exposure and with age. When these pigments were in wider use, it would be quite common to find chrome yellows, with barium sulphate (blanc fix) as a bulking agent. Similarly, chrome yellows were often mixed with yellow ochres to brighten the appearance of the natural earth colour.
Tinting Strength	Very good, as a pure tint (i.e. without extender).
Shade	Lemon, light, mid-yellow, deep to orange shades.
Opacity	Good.
Suitability to Media	Oil (but can turn dark on exposure to atmosphere and show a greenish tinge, when too much oil is used in the milling process).
Drying Rate (in oil)	Fast (lead-based). Sometimes used in oil gilding, co-mixed with oil to act as a mordant.
Defects	Turns greenish or brownish with age, especially in oil films, where contact with acid in the oil can turn the lemon and pale yellow varieties to a greenish tinge very quickly.

Availability/Cost	Until recently, this pigment was cheap and available in many paint ranges. Withdrawn from colour ranges in the early 1990s and now difficult to obtain through pigment suppliers.
Comments	Strontium yellow (PY 32/C.I. 77839), strontium chromate, is similar to chrome yellow, with a bright lemon shade ($SrCrO_4$). This pigment has been hard to find in recent years, due in part to the toxicity of its manufacture. Strontium yellow may also appear under the name "ultramarine yellow".
Special Note	An important artists' pigment. No longer available (from most sources in Europe), due to EU legislation. Chrome green (PG 15) is formed from a mixture between prussian blue and chrome yellow and may vary in shade according to a) the amount of prussian blue to yellow b) the tone of the chrome yellow used (e.g. lemon, mid, deep, etc).
Health & Safety Information	Toxic, lead chromate.

CADMIUM YELLOW (shades)
LIGHT PY 35 – CdSZn
MEDIUM PY 37 – Cds
DEEP PY 37 – CdS
ORANGE PO 20 – CdS. x CdSe

Colour Index Number	PY 35/77205, PY 37/77199, PO 20/77202
ASTM/BWS Rating	ASTM I
Common Names	Cadmium lemon, cadmium yellow pale/light, cadmium yellow medium, cadmium yellow deep/dark, cadmium orange.
Composition and Origin	CdS. The metal cadmium was discovered in 1817 and first used by artists in England in the 1840s. However, due to the scarcity of the material, it was not fully developed as a pigment for artists until the early 20th century. An artificial mineral pigment, pure cadmium sulphide is sometimes mixed with cadmium selenide. Cheaper cadmium pigments may be co-precipitated with barium sulphate. According to ASTM, the pigment can include up to 15% barium sulphate. PO 20:1 is cadmium orange blended with barium sulphate (cadmium lithopone orange, CdS. x CdSe.y$BaSO_4$). The purest grades are derived only from cadmium sulphide and this is generally reflected in the price.
Tinting Strength	Good.
Shade	Cool lemon, light yellow, mid yellow, dark yellow to orange shades.
Opacity	Tends towards transparency in extremely thin layers, otherwise opaque.
Suitability to Media	Stable in all media. Exterior application is not advised, because when cadmium is exposed to damp and/or air, it changes to cadmium carbonate, showing a degree of discoloration.
Drying Rate (in oil)	Slow.
Defects	Can fade, when exposed in combination to damp and sunlight.
Availability/Cost	Expensive but widely used.
Comments	–

Special Note	Mixtures with lead-based colours are not recommended, although mixtures with lead white tend to remain unchanged. Aurora yellow was a patented form of cadmium yellow, developed by Winsor & Newton in 1889. Their catalogue of 1925 suggests that this yellow vies with chrome yellow in terms of opacity and brightness. Orient yellow is a deeper shade of aurora yellow.
Health & Safety Information	Contains cadmium.

ZINC YELLOW PY 36

Colour Index Number	77955
ASTM/BWS Rating	Not tested.
Common Names	Zinc chrome yellow, primrose yellow, citron yellow.
Composition and Origin	An artificial mineral pigment, zinc chromate, $ZnCrO_4$. Developed by Vauquelin, 1809.
Tinting Strength	Weak.
Shade	Cold pale yellow, almost lemon in shade.
Opacity	Semi-opaque.
Suitability to Media	Stable in oil, but reduced in permanence when admixed strongly with white. In water-based media, zinc yellow remains partially soluble and is soluble when in contact with alkalis (i.e. avoid in lime-fresco).
Drying Rate (in oil)	Fast.
Defects	Sensitive to moisture and alkalis.
Availability/Cost	No longer widely available in pigment form: still offered by some Italian manufacturers as prepared oil colour and dry pigment.
Comments	Was formerly used in the production of mixed greens, such as zinc green (with prussian blue). In some cases, such admixtures were further complicated by the inclusion of blanc fix. The author has in recent years bought a variety of zinc greens from old pigment stores in Italy (which were closing down), showing a wide range of colours, from light, acid greens, to murky, subdued shades.
Special Note	–
Health & Safety Information	Toxic.

ORPIMENT PY 39

Colour Index Number	77085
ASTM/BWS Rating	Not tested.
Common Names	Kings yellow (denotes the artificial product).
Composition and Origin	As_2S_3, mineral containing a naturally occurring sulphide of arsenic. It can be prepared artificially from arsenic trichloride and sodium thiosulphate. Due to its extremely poisonous nature, orpiment is used with great caution. Also, because it is sulphide-based, it can react with other pigments.
Tinting Strength	Good.
Shade	Bright yellow, similar to cadmium yellow light or medium.
Opacity	Not especially transparent.
Suitability to Media	Stable in egg tempera, and when used in oil-resin mixtures where the pigment is protected from exposure to the atmosphere and other pigments.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Expensive as dry pigment.
Comments	–
Special Note	In historical paintings, sometimes found admixed with blue (e.g. lapis, azurite) to make green shades.
Health & Safety Information	Toxic, contains arsenic.

COBALT YELLOW, AUREOLIN PY 40

Colour Index Number	77357
ASTM/BWS Rating	ASTM II
Common Names	Sunshine yellow.
Composition and Origin	$CoK_3(No_2)^6].H_2O$. Artificial mineral pigment, from cobalt salts and potassium nitrate – Potassium cobaltinitrite. Introduced as an artists' pigment in the 1860s, primarily as a watercolour.
Tinting Strength	Good.
Shade	A pure golden yellow, similar to true indian yellow when applied as a glaze. When ground in oil, it takes on a slightly greenish cast at full strength but appears as a true yellow when thinned to a glaze.
Opacity	Almost transparent as a glaze colour.
Suitability to Media	Stable in all media, except lime-fresco.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Very expensive. Available in many paint ranges, in all media.
Comments	–
Special Note	–
Health & Safety Information	–

NAPLES YELLOW PY 41

Colour Index Number	77589
ASTM/BWS Rating	ASTM I
Common Names	Antimony yellow.
Composition and Origin	$Pb_3(SbO_4)$. An artificial mineral pigment. Lead antimoniate (lead and antimony oxides). Often confused with lead tin yellow in historical paint samples.
Tinting Strength	Good.
Shade	Lemon, mid-yellow to reddish-yellow shades.
Opacity	Good hiding power, opaque. Heavy powder makes thick paint pastes with stiffish consistency.
Suitability to Media	Stable in oil, lime, casein, egg but some varieties may be liable to darkening (on exposure to sulphurous compounds) in water-based media. Also, in water-based media the heavy powder tends to settle out in mixtures.
Drying Rate (in oil)	Fast (contains lead). Can also be used to speed up drying time of pigments intermixed with it.
Defects	–
Availability/Cost	Hard to find in manufactured ranges, although the pigment is still available from specialist pigment suppliers.
Comments	Naples yellow in modern colour ranges usually refers to the shade rather than the true pigment. Excellent for flesh tints. Avoid using steel palette or painting knives with the dry powder, as this can cause a greenish/darkening effect.
Special Note	Jaune brilliant is a mixed colour, originally based on naples yellow with cadmium yellow, vermilion and lead white. Modern examples may be based on admixtures of lead white (or other whites) with cadmium red and cadmium yellow.
Health & Safety Information	Toxic, contains lead.

LEAD TIN YELLOW, TYPE I PY 46

Colour Index Number	77577
ASTM/BWS Rating	Not tested.
Common Names	Giallorino (as mentioned by Cennini).
Composition and Origin	Pb_2SnO_4, lead stannate, prepared from a heated mixture of lead dioxide with tin dioxide. Thought to be a by-product of the glass-making industry in former times. Two distinct shades can be produced in this manner; at temperatures of around 700-800°C, a cold lemon yellow is achieved. At lower temperatures, a slightly warmer shade is created. Lead tin yellow was often incorrectly identified as either naples yellow or *massicot* in historical paintings. In 1941, the Doerner Institute in Munich identified the presence of tin in lead-based yellow historical paint samples. The pigment was subsequently remade according to chemical analysis, the development of cool lemon and warm yellow shades being effected in the early 1960s.
Tinting Strength	Weak. Best used alone, or as very pale yellow when admixed with lead white.
Shade	Pale lemon, or warm mid-yellow.
Opacity	Both pale lemon and warm shades are milky and opaque when mixed into binder. Lead tin yellow is sometimes found in old paintings as an underpaint, subsequently overpainted with a green glaze (copper resinate), to achieve bright, strong green shades.
Suitability to Media	Stable in oil, tempera and oil-tempera emulsions.
Drying Rate (in oil)	Dries fast (contains lead).
Defects	Can turn black in watery binders (e.g. gum arabic), where the lead content darkens on contact with sulphur in the atmosphere.

Availability/Cost	Available as dry pigment.
Comments	–
Special Note	–
Health & Safety Information	Contains lead, toxic.

LEAD TIN YELLOW, TYPE II PY 46

Colour Index Number	77577
ASTM/BWS Rating	Not tested.
Common Names	Giallorino.
Composition and Origin	Lead and tin oxides, with the inclusion of free tin oxide and silicon (quartz). As with type I, type II may originate from glass colouring fabrication. It is a yellow lead-glass pigment, most probably a by-product of lead crystal glass manufacturing. The inclusion of quartz effects a degree of transparency to the pigment, making it possible to use in glaze techniques. The colour is warmer and stronger than type I. The pigment is sifted through a fine mesh to provide a grind size suitable for use in oil, tempera and egg-oil painting.
Tinting Strength	Weak.
Shade	Warm, translucent yellow.
Opacity	Transparent.
Suitability to Media	Oil, egg-oil emulsions, egg tempera. The grainy particle size makes it unsuitable for use in very thin paint films where the paint film can show a textured finish.
Drying Rate (in oil)	Fast drying.
Defects	May discolour (darken) in aqueous media.
Availability/Cost	Available as dry pigment.
Comments	A transparent glazing pigment with a warm hue.
Special Note	–
Health & Safety Information	Contains lead, toxic.

MASSICOT PY 46

Colour Index Number	77577
ASTM/BWS Rating	Not tested.
Common Names	Litharge (pale varieties); massicot (warmer varieties). Lead monoxide may be named according to the country of origin. For example in France, pigments based on lead oxide are known as "*massicot*".
Composition and Origin	PbO. Manufactured inorganic pigment, derived from lead monoxide (PbO). Manufactured by oxidisation of lead, at temperatures of 500-700°C. At one stage, pale yellows in old paintings were identified as being forms of massicot. However, this is due in part to the fact that while lead was identified in such paint samples, no tests were done to identify the presence of tin. In 1941, the Doerner Institute in Munich identified tin in many paint samples previously thought to contain only lead (such as forms of lead-tin yellow).
Tinting Strength	Weak.
Shade	Pale yellow to warm yellow-orange.
Opacity	Milky, opaque.
Suitability to Media	More stable in oil than other media, but still liable to darken upon contact with sulphides in the atmosphere. Also unstable in dry form, turning paler when exposed to air.
Drying Rate (in oil)	Fast. Often used as a drying agent in old paint medium recipes.
Defects	Unstable in all media (tends to darken), especially in any water-based binder. Due to its particularly heavy nature, tends to settle out in paint mixtures.
Availability/Cost	Inexpensive but never used in artists' paints due to toxicity and instability.
Comments	Discarded as a pigment for most techniques. May have some practical relevance as a drying agent when added to paint mediums or varnishes. For example, in the manufacture of sun-thickened linseed oil, an inclusion of perhaps 10% massicot into the oil bath may impart fast-drying properties to the resultant oil.
Special Note	–
Health & Safety Information	Contains lead, toxic.

NICKEL TITANIUM YELLOW PY 53

Colour Index Number	77788
ASTM/BWS Rating	ASTM I
Common Names	Nickel yellow, lemon yellow (hue), naples yellow (hue).
Composition and Origin	$(Ti,Ni,Sb)O_2$. A group of artificial mineral pigments, developed since the 1960s. Oxides of nickel, titanium and antimony. Available in a variety of shades of cool lemon yellow, yellow-green.
Tinting Strength	Fairly strong.
Shade	Similar to barium lemon yellow, or naples yellow light/lemon.
Opacity	Good.
Suitability to Media	Stable in all techniques.
Drying Rate (in oil)	Slow.
Defects	When mixed with other colours, the opacity of nickel titanium yellow tends to transfer to the co-mixed pigment. This is especially so with transparent pigments, which tend to become lost within mixtures. However, the opacity and bulky nature of paint pastes made with nickel titanium make this pigment an ideal substitute for barium lemon yellow and naples yellow.
Availability/Cost	Widely used (especially in acrylic paints) as lightfast, permanent and safe to use alternatives to barium lemon yellow and genuine naples yellow.
Comments	Soft, fluffy powder, easy to hand-grind into oil colour.
Special Note	–
Health & Safety Information	–

PYRAMID YELLOW PY 108

Colour Index Number	68420
ASTM/BWS Rating	ASTM I/ BWS 8
Common Names	Anthrapyrimidine yellow.
Composition and Origin	$C_{30}H_{15}N_3O_4$. Synthetic organic pigment.
Tinting Strength	Good.
Shade	Warm, mid-yellow, with slightly mustard shade at mass tone. As a thinned glaze, shows a warmer tinge.
Opacity	Tends towards transparent (semi-opaque).
Suitability to Media	Not stable to lime.
Drying Rate (in oil)	Medium.
Defects	–
Availability/Cost	–
Comments	Permanent to light.
Special Note	Requires wetting agent.
Health & Safety Information	–

IRGAZINE YELLOW PY 110

Colour Index Number	56280
ASTM/BWS Rating	ASTM I/ BWS 7-8
Common Names	Isoindolinone yellow, chromophtal yellow.
Composition and Origin	Synthetic organic pigment, tetrachloroisoindolinone. Introduced 1960s.
Tinting Strength	High.
Shade	Bright, warmish yellow, similar to cadmium yellow mid-deep.
Opacity	Good, similar to cadmium pigment.
Suitability to Media	Stable in all media, including lime.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	–
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

PALIOTOL YELLOW PY 139

Colour Index Number	56298
ASTM/BWS Rating	ASTM I
Common Names	Isoindoline yellow.
Composition and Origin	$C_{16}H_9N_5O_6$. Synthetic organic pigment, introduced 1960s.
Tinting Strength	Good.
Shade	Warm yellow-orange, reddish yellow.
Opacity	Semi-transparent.
Suitability to Media	Not stable to lime.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	–
Comments	Similar in tone to cadmium yellow deep but with more transparency.
Special Note	Requires wetting agent.
Health & Safety Information	–

PRIDERITE YELLOW   PY 157

Colour Index Number	77900
ASTM/BWS Rating	Not tested.
Common Names	Nickel barium, titanium primrose.
Composition and Origin	Artificial mineral pigment. A complex matrix of nickel, barium and titanium.
Tinting Strength	Medium.
Shade	A bright lime green-yellow (similar in shade to the old chrome based cinnabar green hue).
Opacity	Good.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Available as dry pigment.
Comments	–
Special Note	–
Health & Safety Information	–

BISMUTH-VANDATE YELLOW PY 184

Colour Index Number	11777
ASTM/BWS Rating	Not tested.
Common Names	Bismuth yellow, bristol yellow, sicopal yellow.
Composition and Origin	Artificial mineral pigment, mixed crystal of the bismuth-vanadium oxide system. Stable and lightfast. Introduced 1980s. A new class of bismuth-based pigments, known as bristol yellows have recently been introduced.
Tinting Strength	Good.
Shade	Very pure, strong bright lemon shade. Bristol yellows are also available, ranging in shade from light yellow, mid-yellow to reddish yellow. Bristol yellows are opaque, permanent colours which offer a good alternative to zinc yellow, chrome yellow or cadmium yellow.
Opacity	Good – use in mixtures with transparent synthetic organic pigments to create opaque mixtures.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	–
Defects	Lemon shades may appear greenish when poorly mixed with oil.
Availability/Cost	Becoming available in paint ranges.
Comments	–
Special Note	–
Health & Safety Information	–

INDIAN YELLOW GENUINE

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	–
Composition and Origin	$C_{19}H_{16}MgO_{11}$. $6H_2O$. Magnesium salt of euxanthic acid. True indian yellow is derived from the urine of cows fed on mango leaves. The urine is mixed with a clay base to make a purée, which is then dried out and ground into a lightfast powder. It is now banned on grounds of cruelty. Indian yellow was formerly imported from Calcutta to London, the pigment being produced at Monghyr, in the Indian state of Bihar.
Tinting Strength	Good.
Shade	A strong, warm yellow orange.
Opacity	Excellent transparency.
Suitability to Media	Stable in all media but destroyed by alkalis, so never used in lime-fresco.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	No longer available, except perhaps in the trade of antique pigments between collectors.
Comments	Modern synthetic organic pigments such as Indian Yellow Substitute (PG10) can make a reliable alternative. Earlier synthetic organic pigments such as tartrazine lake are less permanent, especially when mixed with whites and exposed to direct light.
Special Note	By 1925, Winsor & Newton record that the genuine colour being "no longer available", was replaced at that time by a coal tar yellow with a similar shade.
Health & Safety Information	–

GAMBOGE Natural Yellow 24

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Camboge, gomma gutti (Italian).
Composition and Origin	Gamboge is a tree resin, from the species *Garcinia*, found in India and South East Asia. In the crude "pipe" form, the resin, or sap is tapped from the tree, collected into a mould and left to dry. The resin contains both pigment and binding agent. With just a brush and water, one can take colour from the solid resin and apply the resultant "paint" to paper as a watercolour (i.e. it requires no binding medium). Gamboge is sold in lump form or as a powder.
Tinting Strength	Weak when admixed with other pigments, although in watercolour mixed greens can be made by combination with small amounts of prussian blue or indigo.
Shade	A warm orange-yellow.
Opacity	Very transparent, often used as a colouring agent for alcohol (sandarac/shellac) varnishes, in the toning of furniture or musical instruments.
Suitability to Media	The resin partially dissolves in water to form a sticky, resinous form of watercolour (i.e. does not require the addition of gum arabic to adhere to paper). Gamboge can also be dissolved in alcohol and warm turpentine and thus used as a colouring agent for transparent warm-yellow varnishes, such as those employed over silver leaf, to imitate gold.
Drying Rate (in oil)	Soluble in oil, therefore unsuitable.
Defects	Not fast to light (fugitive).
Availability/Cost	Available in powder or resin form.
Comments	Substitute with cobalt yellow.
Special Note	–
Health & Safety Information	Toxic.

STIL DE GRAIN

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Brown lake, yellow lake, persian lake, buckthorn lake, dutch pink, yellow carmine, italian pink.
Composition and Origin	$C_{16}H_{12}O_7$. Plant-based pigment, derived from unripe buckthorn berries. Similar yellow "lake" pigments could be processed from quercitron bark and fustic. The plant berries are steeped in a lye (potash), then precipitated with alum to create a translucent yellow "lake" pigment. Some yellow pigments derived from plant material (e.g. weld) may be struck on to opaque substrates such as finely ground marble dust.
Tinting Strength	Weak.
Shade	Warmish yellow, can vary from batch to batch of pigment.
Opacity	Very transparent, especially in oil.
Suitability to Media	Compatible with all media, except lime, but liable to fade on exposure to sunlight.
Drying Rate (in oil)	Slow.
Defects	Fugitive to light.
Availability/Cost	Available as dry pigment, also as dried berries which can be hand-treated with potash and alum to create a pigment.
Comments	Sometimes used as overpaint, on top of blue underpaint, to achieve a green colour. However, may partially or wholly fade when used in this manner. In oil, the binder saturates the pigment to give very dark, almost brown-yellow character; in watercolour, the pale, warm yellow hue is preserved. In old watercolour ranges, various mixed hues were prepared using stil de grain as an ingredient: Olive green – stil de grain, indian yellow genuine, indigo Olive lake – stil de grain, bone black (brown shade), ultramarine.

Special Note	Sap green is also obtained from buckthorn berries, but is expressed from the ripe (dark) fruit. By tradition it is prepared as a watercolour paint by immersing the berries into a warm solution of alum and water. To ease the process, the berries may be left to steep in water for a few hours, drained and then crushed in a pestle and mortar before placing in the alum-water bath. The alum-water solution with the berries in it is slowly stirred over a gentle heat for 15-30 minutes. The resulting liquid is strained through muslin to form a thick syrup or jelly, which is applied in this semi-liquid state as a watercolour paint. When first applied, the colour is a warmish green, turning a warm yellow-brown upon drying. Sap green in this form is very unstable to light, bleaching out quickly when exposed to sunlight, turning a poor green-brown. Genuine sap green is no longer available in this form, other than by processing the berries by hand. Early 20th century substitutes for this colour were derived from non-lightfast coal tar colours, such as alizarin green. In recent years, sap green is usually a mixed colour, based on more permanent synthetic organic pigments.
Health & Safety Information	–

INDIAN YELLOW (SUBSTITUTE) PG 10

Colour Index Number	12775
ASTM/BWS Rating	ASTM I
Common Names	Nickel azo yellow.
Composition and Origin	Nickel-based synthetic organic pigment. A reliable alternative to genuine Indian yellow (not available in Europe since the 1920s).
Tinting Strength	Good.
Shade	Greenish as mass tone, gives a transparent yellow when used as glaze.
Opacity	Gives perfect transparent glazes.
Suitability to Media	–
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Relatively expensive, but high tinting strength means a little goes a long way as a glaze colour.
Comments	–
Special Note	Requires wetting agent. Has a more greenish tone than genuine indian yellow.
Health & Safety Information	–

ORANGE PIGMENTS

CINQUASIA YELLOW GOLD PO 48

Colour Index Number	–
ASTM/BWS Rating	ASTM I
Common Names	Quindo gold, quinacridone gold.
Composition and Origin	$C_{20}H_{12}N_2O_2$. Synthetic organic pigment.
Tinting Strength	Good.
Shade	Warm yellow-orange, similar to raw sienna but with higher tinting strength.
Opacity	Tends towards transparent.
Suitability to Media	Difficult to disperse without a wetting agent, paint film may not remain consistent over time. In all other respects, stable to all media.
Drying Rate (in oil)	Medium-slow.
Defects	Some uncertainties remain with regard to stable film formation, more likely to become apparent in cheaper paint ranges, where less time has been spent on mixing.
Availability/Cost	Available in some acrylic ranges and as dry pigment.
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

CINQUASIA RED GOLD PO 49

Colour Index Number	–
ASTM/BWS Rating	ASTM I
Common Names	Quindo red gold, quinacridone red gold, quindo gold deep.
Composition and Origin	$C_{20}H_{12}N_2O_4$. Synthetic organic pigment.
Tinting Strength	Good.
Shade	Warm red-orange, yellow-orange, similar to burnt sienna but with higher tinting strength.
Opacity	Tends towards transparent.
Suitability to Media	Difficult to disperse without a wetting agent, paint film may not remain consistent over time. In all other respects, stable to all media.
Drying Rate (in oil)	Medium-slow.
Defects	Some uncertainties remain with regard to stable film formation, more likely to become apparent in cheaper paint ranges, where less time has been spent on mixing.
Availability/Cost	Available in some acrylic ranges and as dry pigment.
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

PALIOTOL ORANGE PO 59

Colour Index Number	12075
ASTM/BWS Rating	ASTM II/ BWS 8
Common Names	Permanent orange, dinitraniline orange.
Composition and Origin	$C_{16}H_{10}N_4O_5$. Organic synthetic monoazo pigment.
Tinting Strength	Good.
Shade	Bright red-orange.
Opacity	Tends towards transparent.
Suitability to Media	Stable to all media (may streak or run when in contact with mineral solvents).
Drying Rate (in oil)	Medium.
Defects	–
Availability/Cost	–
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

HOSTAPERM ORANGE PO 60

Colour Index Number	11782
ASTM/BWS Rating	ASTM I
Common Names	Benzimidazolone orange HGL.
Composition and Origin	Synthetic organic pigment. Monoazo benzimidazolone.
Tinting Strength	Good.
Shade	Warm orange as mass tone, thins to warm orange glaze.
Opacity	Good transparency.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	–
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

ISOINDOLINE ORANGE PO 61

Colour Index Number	11265
ASTM/BWS Rating	BWS 8
Common Names	Chromophtal orange.
Composition and Origin	Synthetic organic pigment.
Tinting Strength	Good.
Shade	Warm, dark orange as mass tone, takes on a colder hue when diluted to a thin glaze.
Opacity	Good transparency as glaze.
Suitability to Media	–
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Available as dry pigment and in some updated oil colour ranges.
Comments	Good glazing colour.
Special Note	Requires wetting agent.
Health & Safety Information	–

IRGAZINE ORANGE PO 73

Colour Index Number	–
ASTM/BWS Rating	BWS 8
Common Names	Pyrrol orange, irgazine orange DPP (Di-Keto-Pyrrolo-Pyrrol).
Composition and Origin	Synthetic organic pigment, introduced 1980s.
Tinting Strength	Good.
Shade	Warm, deep orange.
Opacity	Relatively opaque – glazes when thinned right down with binder/medium.
Suitability to Media	Stable in all media, including lime.
Drying Rate (in oil)	Slow.
Defects	The raw pigment tends to form together in clumps. Before combining into binder, break the particles down and separate them by wetting first with alcohol (watercolour, casein); a disperse agent for acrylic such as orotan (acrylic); mineral spirit (oil).
Availability/Cost	Available as dry pigment.
Comments	Offers an excellent alternative to cadmium pigments, with a similar opacity.
Special Note	Requires wetting agent.
Health & Safety Information	–

RED LEAD PR 105

Colour Index Number	77578
ASTM/BWS Rating	Not tested.
Common Names	Minium, saturn red, orange mineral.
Composition and Origin	Red tetroxide of lead, Pb_3O_4. Manufactured by heating either lead white or litharge (massicot) over a prolonged period at a constant temperature of 480°C. If the temperature varies during manufacture, the colour can be ruined. Lead red is often found in gilding, as an underpaint and as a mordant for oil gilding. Its fast-drying characteristic is also utilised for the coating of iron exterior structures (e.g. bridges).
Tinting Strength	Good.
Shade	Bright red-orange.
Opacity	Good.
Suitability to Media	Not stable in any medium, especially water-based binders.
Drying Rate (in oil)	Fast.
Defects	Turns brown in oil (on reaction to acidic compounds); turns black in water-based media (on reaction to sulphides). When ground in oil, tends to harden quickly when packed into tubes.
Availability/Cost	Inexpensive, in pigment form only.
Comments	Replaced by more reliable pigments (e.g. cadmium orange, irgazine orange).
Special Note	–
Health & Safety Information	Toxic, contains lead.

TITANIUM ORANGE PBr 24

Colour Index Number	77310
ASTM/BWS Rating	Not tested.
Common Names	Chrome titanate orange, ironstone brown.
Composition and Origin	An artificial mineral pigment. Cr-Sb-Ti, mixed phase system.
Tinting Strength	Moderate (weak in mixtures with other colours).
Shade	Dull orange.
Opacity	Good.
Suitability to Media	Found in some acrylic paint ranges but may also be useful in the making of gouache colours, due to its opacity.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Available as dry pigment and in some paint ranges.
Comments	–
Special Note	–
Health & Safety Information	–

REALGAR

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Arabic name: *Rahj al ghar* "powder of the mine".
Composition and Origin	Sulphide of arsenic, similar to orpiment, naturally occurring in mineral form. Can also be prepared artificially. As_2S_2. Often found in nature in conjunction with or alongside orpiment. Sometimes confused with red lead, which is a similar colour.
Tinting Strength	Poor, due to crystalline structure.
Shade	Solid orange-red.
Opacity	Good.
Suitability to Media	Often found in egg tempera paintings, sometimes admixed with blues to make greenish shades.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Expensive.
Comments	–
Special Note	–
Health & Safety Information	Toxic, contains arsenic.

RED PIGMENTS

STUDIO RED PR 3

Colour Index Number	12120
ASTM/BWS Rating	BWS 7
Common Names	Helio red, lithol red, scarlet lake*, imitation vermilion, monoazo red, hansa red, toluidine red.
Composition and Origin	Synthetic organic pigment (based on organic dyestuff). Introduced early 1900s.
Tinting Strength	Good, although cheaper grades may be premixed with extender which gives a more subdued effect.
Shade	Variety of shades: mid-red to deep red, particularly shades close to vermilion.
Opacity	As pure pigment, transparent: when admixed with extender, less so.
Suitability to Media	–
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Often used in place of cadmium reds, or as substitute for vermilion, especially in cheaper paint ranges.
Comments	When mixed strongly with white, prone to fading.
Special Note	Requires wetting agent. Scarlet lake is an old colour name, referring to the preparation of alizarin crimson with vermilion, or vermilion with natural madder lake or carmine (as commonly used in 18th and 19th century portrait painting practice).
Health & Safety Information	–

PERMANENT RED/CARMINE PR 5/PR 170/PR 9/PR 7/PR 194

Colour Index Number	PR 5/C.I. 12490, PR 170/C.I. 12475, PR 9/C.I. 12460, PR 7/C.I. 12420, PR 194/C.I. 71100
ASTM/BWS Rating	PR 5 – ASTM II – Napthol Red ITR – $C_{30}H_{31}ClN_4O_7S$ PR 170 – ASTM II – Napthol Red/Crimson – $C_{36}H_{22}N_4O_4$ PR 9 – ASTM II – Napthol Red AS-OL – $C_{24}H_{17}Cl_2N_3O_3$ PR 7 – ASTM I – Napthol Red AS-TR – $C_{25}H_{19}Cl_2N_3O_2$ PR 194 – ASTM I – Perione/Permanent Red Dark GOLO
Common Names	Formerly: para red (PR 1/C.I. 12070); updated: permanent red/carmine, napthol red, napthol crimson.
Composition and Origin	Synthetic organic group of pigments, with variable permanence (despite the name!). Early permanent reds (e.g. para red) were based on azo-napthol synthetic dyestuffs and prone to fading on exposure to light. These colours performed satisfactorily when used neat. When admixed with white, their tendency to fade made them suitable only for cheaper paints. The modern equivalents to these colours have better permanence and are widely used, as relatively stable alternatives to the expensive cadmium pigments. The naming of these colours is rather confusing: some napthol red pigments are not reliably permanent to light. Choose the more lightfast varieties, as recommended above – look for the Colour Index Name on tube labelling and in catalogues.
Tinting Strength	Good.
Shade	Mid-red, deep red to crimson, carmine shades.
Opacity	Very transparent, especially when compared to cadmium reds.
Suitability to Media	–
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Offered in most paint ranges, as alternative to cadmium reds.
Comments	The new carmine shades have great intensity.
Special Note	Requires wetting agent.
Health & Safety Information	–

CADMIUM RED — VERMILION ORANGE PO 23 – CdS. x HgS
RED PR 113 – CdS. x HgS
LIGHT PR 108 – CdS. x CdSe
MEDIUM PR 108
DEEP PR 108

Colour Index Number	PO 23/77201, PR 113/77201, PR 108/77202
ASTM/BWS Rating	ASTM I
Common Names	Selenium red, cadmium scarlet, cadmium vermilion, cadmium red pale/light, cadmium red medium, cadmium red deep/dark, cadmium bordeaux, cadmium brown.
Composition and Origin	An artificial mineral pigment, produced by heating cadmium sulphide with the element selenium. Cadmium vermilion orange is a solid solution of mercury sulphide in cadmium sulphide. Introduced for artists in the 1920s – a permanent replacement for vermilion.
Tinting Strength	Good.
Shade	Warm orange, through bright vermilion tone to deep red, purple-red (bordeaux), red-brown.
Opacity	Good.
Suitability to Media	Stable to all media, in lime-fresco suitable for indoor work only.
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	Expensive but widely used.
Comments	More opaque than the synthetic organic red pigments, which are often used to imitate cadmium red. The best grades are pure, but some varieties may include up to 15% barium sulphate as an extender (PR 108:1).
Special Note	–
Health & Safety Information	Contains cadmium.

ALIZARIN CRIMSON PR 83

Colour Index Number	58000
ASTM/BWS Rating	ASTM III, as oil colour
Common Names	Madder lake synthetic, alizarin carmine, crimson lake, alizarin madder lake.
Composition and Origin	$C_{14}H_8O_4$. A synthetic organic pigment, based on the dyestuff alizarin. Alizarin is the most lightfast of the colourants derived from natural madder root. (Madder root was previously processed to produce natural madder lake). Alizarin was first separated from the other colourants in madder root, in 1826. The dyestuff alizarin was subsequently synthesised in 1868.
Tinting Strength	Dark shades quite strong.
Shade	Blue-red, some varieties are a bright red (alizarin crimson light).
Opacity	Transparent.
Suitability to Media	Not stable to lime fresco.
Drying Rate (in oil)	Slow – thick paint dries with wrinkling.
Defects	Drying problems. Can fade against white grounds and in mixtures with whites. Performs better when applied over darker ground colours.
Availability/Cost	Widely used, fairly inexpensive.
Comments	Use as thin glazing colour.
Special Note	Requires wetting agent. In some paint ranges, alizarin crimson is offered with the name permanent alizarin crimson. This may relate to the use of anthraquinone red (PR 177/C.I. 65300) – $C_{28}H_{16}N_2O_4$, which is stable and lightfast in all media, although in tints with white it may exhibit lower stability to light. To mix a lightfast approximation of alizarin crimson, the following colours can be combined: quinacridone red (PV 19, red-shade), perylene red (PR 149) and ultramarine blue (PB 29).
Health & Safety Information	–

CHROME RED PR 104

Colour Index Number	77605
ASTM/BWS Rating	Not tested.
Common Names	Chromate red, molybdate of lead, chinese red.
Composition and Origin	$Pb_2(OH)^2CrO_4$. Artificial mineral pigment, developed since 1820s.
Tinting Strength	Good. Lead chromate red.
Shade	Bright pillar-box red, also in shades of orange red*, red-orange, mid-red, deep red.
Opacity	Good.
Suitability to Media	Previously used in oil colours. However, not permanent in any media.
Drying Rate (in oil)	Fast.
Defects	Turns dark in oil, sometimes with a greenish or brownish cast.
Availability/Cost	Sometimes still available as a dry pigment.
Comments	Withdrawn from use due to toxicity of manufacture and exposure to end user.
Special Note	Satisfactory substitutes can be found among the cadmium reds or irgazine reds. *Chrome orange is a co-mixture of chrome yellow and chrome red.
Health & Safety Information	Contains lead, chrome. Toxic.

VERMILION PR 106

Colour Index Number	77766
ASTM/BWS Rating	ASTM I
Common Names	Cinnabar (technically refers to the mineral form of the pigment), chinese vermilion, scarlet vermilion, orange vermilion, pale vermilion, etc.
Composition and Origin	HgS. An artificial mineral pigment, based on mercuric sulphide. The natural mineral (cinnabar, mercury ore) produces a darker, brownish pigment and has been used as a painting material from classical times. In Chinese painting, the pigment dates back to prehistory. In Europe, mineral cinnabar was formerly mined in Almaden, Spain and Monte Amiata in Italy. The artificial "wet" and "dry" processes for producing vermilion date from the 13th century, although industrial production began in the late 18th century. The permanence of vermilion is disputed: for many decades, the appearance of random black areas on paintings made with vermilion was blamed on a defect of the pigment. Recent studies seem to indicate that this blackening effect may be caused by admixtures with chrome red or red lead pigment. Curiously, vermilion is rated ASTM I as an oil paint. In the meantime this important pigment has disappeared from most oil colour ranges. Despite the confusion surrounding vermilion, it is still sought after by artists and retains its historic significance within the painters' palette.
Tinting Strength	Good.
Shade	Warm, bright red, sometimes slightly pinky. Darker shades can have a dusky appearance.

Opacity	Good.
Suitability to Media	Oil, tempera, watercolour. In lime-fresco it is generally safely applied in fresco secco (bound in animal glue, egg or casein and applied over dried layers of lime), although examples of fresco paintings survive that are painted entirely into lime.
Drying Rate (in oil)	Very slow.
Defects	Some varieties of processed vermilion are prone to reverting to black mercuric sulphide.
Availability/Cost	Expensive. Vermilion has all but vanished from modern oil colour ranges due to its reputed toxicity and apparent impermanence, coupled with its scarcity in pigment form. Specialist pigment suppliers offer the dry pigment in light and dark shades. The mineral form is also available.
Comments	A soft, warm red with unique qualities.
Special Note	Vermilion can be considered stable in lime-fresco techniques, when saturated in lime-water and left to dry, then re-powdered (in a pestle and mortar), and re-saturated with lime-water. This process, when undertaken five times (or more), will help encapsulate the pigment particles and so avoid contamination with atmospheric pollutants. After the fifth saturation with lime-water, the material is re-ground to a powder and added as normal (with water only) and applied to fresh intonaco.
Health & Safety Information	Contains mercury.

QUINACRIDONE PINK/RED (Permanent Rose)

MAGENTA PR 122 - $C_{22}H_{16}N_2O_2$
RED PR 192
SCARLET PR 207 - $C_{20}H_{12}N_2O_2$
VIOLET PV 19 - $C_{20}H_{12}N_2O_2$

Colour Index Number	PR 122/73915, PR 192/NA, PR 207/NA, PV 19/73900
ASTM/BWS Rating	ASTM I
Common Names	Quinacridone red, quinacridone scarlet, quinacridone violet.
Composition and Origin	A group of synthetic organic pigments, introduced from 1950s.
Tinting Strength	Very high.
Shade	Bright pink-red, with violet tinge, shades available from mid-red, to pink-red, violet-red, violet.
Opacity	Very transparent.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Slow, usually has drier added in tube oil colour.
Defects	–
Availability/Cost	Expensive but very strong, can be extended considerably in cheaper paint ranges. Other synthetic reds, such as perylene red and paliogen maroon are less expensive and may become easier to obtain.
Comments	Dark red/crimson/rose shades offer a lightfast alternative to alizarin crimson, which can be applied in glazes against pale grounds, or in admixtures with white.
Special Note	Requires wetting agent. PV 19 can be sold as either a red, red-violet or violet shade, according to manufacturer.
Health & Safety Information	–

PERYLENE RED PR 149

Colour Index Number	71137
ASTM/BWS Rating	ASTM I
Common Names	Anthraquinone red, perylene red BL.
Composition and Origin	$C_{40}H_{26}N_2O_4$. Synthetic organic pigment.
Tinting Strength	Strong.
Shade	Bright warmish red. Tints with white tend towards pink-red.
Opacity	Transparent, excellent for glazing.
Suitability to Media	Stable in all media, except lime-fresco.
Drying Rate (in oil)	Medium.
Defects	–
Availability/Cost	Becoming available in updated paint ranges.
Comments	–
Special Note	–
Health & Safety Information	–

SCARLET RED PR 168

Colour Index Number	58300
ASTM/BWS Rating	ASTM II
Common Names	Anthranthrone red, anthraquinone red or scarlet.
Composition and Origin	$C_{22}H_8Br_2O_2$. Synthetic organic pigment. Brominated anthranthrone, introduced from 1913 onwards.
Tinting Strength	Good.
Shade	Bright red, similar to cadmium vermilion shade.
Opacity	Good transparency.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Medium-Slow.
Defects	–
Availability/Cost	–
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

PALIOGEN MAROON PR 179

Colour Index Number	71130
ASTM/BWS Rating	ASTM I
Common Names	Perylene maroon, indanthrene red, palamid bordeaux.
Composition and Origin	$C_{26}H_{14}N_2O_4$. Synthetic organic pigment. Perylene. Production dates from 1959: introduced in artists' colours in recent years.
Tinting Strength	Good.
Shade	Warm, deep crimson. Similar to alizarin crimson but deeper in shade.
Opacity	Good transparency.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Slow.
Defects	Difficult to disperse, may take longer to mull than other pigments, in order to create a smooth paint paste.
Availability/Cost	Available as pigment and in some updated oil colour ranges.
Comments	A lightfast alternative to alizarin, with a warmer tone.
Special Note	Requires wetting agent.
Health & Safety Information	–

POTTER'S PINK PR 233

Colour Index Number	77301
ASTM/BWS Rating	Not tested.
Common Names	Pink colour, chrome-tin pink.
Composition and Origin	An artificial mineral pigment, from either roasted chromium and zinc oxides (pink colour), or roasted chromium and tin oxides (potter's pink), or roasted chromium, aluminium and tin. Discovered in the 1790s in connection with English pottery in Staffordshire, both forms of this deep pinkish colour were formerly used in the ceramics industry.
Tinting Strength	Weak.
Shade	Dull, deep pink, available in light and dark shades.
Opacity	Opaque.
Suitability to Media	Used in watercolour painting during the 18th and 19th centuries. Stable to lime.
Drying Rate (in oil)	–
Defects	Weak tinting strength and heavy, dumpy powder renders this pigment unsuitable to manufactured paints.
Availability/Cost	Expensive and only available in pigment form.
Comments	A subtle, dull pink, of particular interest to fresco painters and also to artists working with strong water-based binders such as casein applied to strong paper.
Special Note	–
Health & Safety Information	–

CARMINE **Natural Red 4 (carmine from cochineal), Natural Red 3 (kermes red lake)**

Colour Index Number	75470 (carmine from cochineal) 75460 (kermes red lake)
ASTM/BWS Rating	Not tested.
Common Names	Carmine lake, cochineal (Coccus cacti).
Composition and Origin	$C_{18}H_{12}O_9$ or $C_{22}H_{20}O_{13}$. Red lake pigments date back to antiquity. Prior to the introduction of carmine derived from the cochineal insect (after the discovery of the Americas by Columbus in 1492), red lakes processed from the kermes insect (*Kermesillicis*) were widely used in Europe. The colouring matter, kermes acid, is extracted from the female insects, by boiling with potash, then precipitation on to an alum base to make a "lake" pigment. The kermes insect was common in the Mediterranean countries of southern Europe, feeding on oak trees. A similar insect, *Coccus polonicus,* in northern Europe (especially Poland) was also used for making red lakes. By contrast to carmine lakes from cochineal, Kermes lakes have less tinting strength and a weaker colour. Kermes was once a celebrated and important dyestuff for textiles, at times more important than madder. Since the introduction of the cochineal insect to Europe in the 1500s it fell out of favour both as a dyestuff and as a colour for painting. The discovery of the new world in 1492 by Christopher Columbus, heralded the introduction to Europe of a very important colouring agent: carmine red lake from the cochineal insect. The colour is derived from the bodies of the insects, which have been fed exclusively on the nopal cactus. Initially, Spain had exclusive rights over the importation to Europe of cochineal. However, eventually, the process was copied in India, where the same type of cactus plant was specially imported to enable cultivation. Today, cochineal is still farmed on the Spanish Canary Islands and in Peru and Chile. The pigment is formed from an initial dye base. The liquid dye is attached to a substrate (e.g. alumina) by precipitation. In the trade, naccarat carmine is the most applicable form for use in oil paints and varnishes.
Tinting Strength	Good.

Shade	Carmine from cochineal is a strong red-crimson.
Opacity	Excellent transparency.
Suitability to Media	Poor permanence: fades in strong sunlight.
Drying Rate (in oil)	Slow.
Defects	Fugitive to light.
Availability/Cost	Expensive, but still found in some oil paint ranges.
Comments	–
Special Note	Requires wetting agent. Burnt carmine is an old colour, prepared by calcining carmine pigment. Indian purple is a fugitive preparation of carmine on a copper base (obsolete).
Health & Safety Information	–

NATURAL MADDER Natural Red 9

Colour Index Number	75330
ASTM/BWS Rating	ASTM II
Common Names	Madder lake, rose madder, rose dore, etc.
Composition and Origin	$C_{14}H_8O_4$. Dyestuff from the roots of the madder plant have been used since antiquity for the dyeing of cloth and for the preparation of colour for painting. The dye extract can be struck on to a substrate to provide a pigment. The exact methods used to gain pigment from the madder plant is open to interpretation: a great many recipes could be quoted and all may have credence. Until the mid-19th century, the production of dyestuffs from madder was of great importance: all over Europe, but especially in France, madder cultivation and processing was common. Often, the dye was used to colour tunics worn by the military and, as a consequence, the madder industry was buoyant. Madder has been employed as pigment since the time of the Egyptians. In some periods, the use of scale insects such as kermes may have been more prevalent than that of madder. In some instances, makers derived the colour not from the actual roots of the madder plant, but from waste cuttings of dyed cloth, the cast-offs from textile production. Such dyed fabrics were immersed into a mordant bath to recover the dyestuff, the liquid then being processed into pigment by mixture with alum. Madder contains purpurin with ruberythric acid: from these dyestuffs, a more stable, reliable dyestuff, known as alizarin (1,2 dihydroxyanthraquinone) is extracted from the plant roots, by treatment with dilute sulphuric acid (3-4%). The dyestuff is then precipitated on to a base of alum, then washed thoroughly to create a stabilised "lake" pigment. Natural madder lake pigments tend to contain some residual quantities of purpurin: this gives natural madder lakes their characteristic warm tinge. Purpurin is understood to be less lightfast than alizarin: in practice this may lead to a loss of brilliance of depth of a paint film, or in some cases, partial fading of the colour in the paint film. By contrast to natural madder

	lakes, modern, synthetic alizarin pigment has a cold, sharp edge. In 1868, the principal colouring matter from madder, alizarin, was first commercially synthesised, precipitating the demise of the madder industry. There is some debate as to the relative lightfastness of synthetic alizarin and natural madder lake. It is suggested by some colourmakers that natural madder is more lightfast than alizarin crimson. This seems to be confirmed by ASTM ratings. As with alizarin crimson, natural madder is prone to fading when admixed with white, or when applied as glaze on to pale ground colour.
Tinting Strength	Weak.
Shade	Warm light pink (as powder); dark crimson (as oil colour).
Opacity	Very transparent as glaze.
Suitability to Media	Stable in all media, but liable to fade in lime-fresco.
Drying Rate (in oil)	Very slow.
Defects	Liable to fade on exposure to sunlight.
Availability/Cost	Expensive. Still offered as prepared paint and in pigment form. The production of madder lake is a costly, time-consuming business.
Comments	A simple method to gain pigment from madder root: take 1kg of dried madder roots (from plants that are 2-3 years old, grown in chalky soil). Place in a heat resistant glass vessel (e.g. pyrex). Immerse into enough cold water to cover the roots. Add 200g, powdered potash (K_2CO_3), stir. Potassium dichromate can be used in place of potash: this is available in the form of pastilles which dissolve into cold water. Potassium dichromate can be affected by light and needs to be stored in a dark brown glass bottle, or in a closed cupboard. Potash is wood ash and this is what would have been used in old recipes for madder lake; the modern product is synthetically produced. Place on a low heat (ideally in a double boiler). Do not let contents boil. Simmer for 1-2 hours. A deep red-purple colour will be extracted from the roots, in the form of a gloopy syrup. The longer the liquid is left to boil, the greater

its viscosity. It is possible to make madder lake without resorting to any heat whatsoever, but heating does however give a more controllable, concentrated liquid that is easier to manipulate.

Pour the liquid into a new container, strain the roots and other debris so that you are left with a coloured liquid solution. This "dyestuff" can then be fixed on to a base of rock alum. Take 500g alum $K_2Al_2(SO_4)$, pour into the liquid dyestuff and leave to steep for 2-3 days. Pour off the coloured water that collects above the settled sediment. Keep the sediment, and dry it by first pouring on to filter paper to remove any remaining dye, then spreading on to a porous surface. A brick is an ideal surface, or perhaps a concrete paving slab – any stone structure with a little porosity. Alternatively, spread the colour paste over a sheet of blotting paper, overlaid with a piece of fine mesh muslin. The muslin stops the alum particles from absorbing into the paper. Once dry, the coloured alum can be scraped from the muslin into a pestle and mortar. Pulverise the coloured alum, to reduce the particle size. Place the dried powder/pieces into a container and fill with cold water to cover. Leave to settle for 2-3 days, pour off the resulting coloured liquid and again, spread the alum paste on to a porous surface. This process is repeated 3-4 times, until the alum paste stops giving out dye (i.e. the water in which the alum-paste is steeped remains colourless upon settlement). This process is very lengthy, perhaps taking 5-6 weeks to produce thoroughly washed pigment. After each washing and drying, the "pigment" should be ground in the pestle and mortar, to gain a fine grain size.

The final product, madder lake, is ideally a warm, deep red-crimson. However, the exact colour will alter from batch to batch so that it is extremely difficult to obtain matches. Some recipes call for the inclusion of ground egg shells (calcite), or very fine chalk (e.g. calcium carbonate, whiting chalk, with mesh size 20) or fine marble dust with the alum: this may reduce transparency but increase the brilliance of the colour.

Special Note	Requires wetting agent. Obsolete forms of natural madder (the particular hue indicated here is sometimes matched in modern paint substitutes): Rose dore – a variation of madder, with a scarlet tinge Brown madder – warm red-brown Madder carmine – rich deep red madder lake Ruben's madder – warm orange-brown.
Health & Safety Information	–

DRAGON'S BLOOD **Coloured Natural Resin**

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	–
Composition and Origin	A tree resin from Indonesia, from the palm, *Calamus draco*. The best quality is that which is tapped from the tree, then left to set into a round ball, or square/rectangular form. To signify high quality, these "lump" forms of dragon's blood are stamped with a gold seal. The resin has a strong red-brown tinge and, when formed into a solution, provides a clarified (varnish) film, with pink-red or orange-red colour.
Tinting Strength	Weak.
Shade	Pink-red or red-orange, according to source.
Opacity	Transparent.
Suitability to Media	Soluble in alcohol only, making it suitable as a glaze over dried layers of egg tempera paint, or as a varnish over gold, silver or tin leaf to enhance/warm the surface colour. Dragon's blood is partially soluble into turpentine, when oil of spike lavender is added. In this form it can be used as a coloured varnish (for aged effects) on to dried oil paint.
Drying Rate (in oil)	–
Defects	Dragon's blood fades in direct sunlight, showing as a dull red-brown.
Availability/Cost	Available in lump (resin) form, or as a pulverised powder.
Comments	–
Special Note	–
Health & Safety Information	Toxic.

GUBBIO RED PBr 23

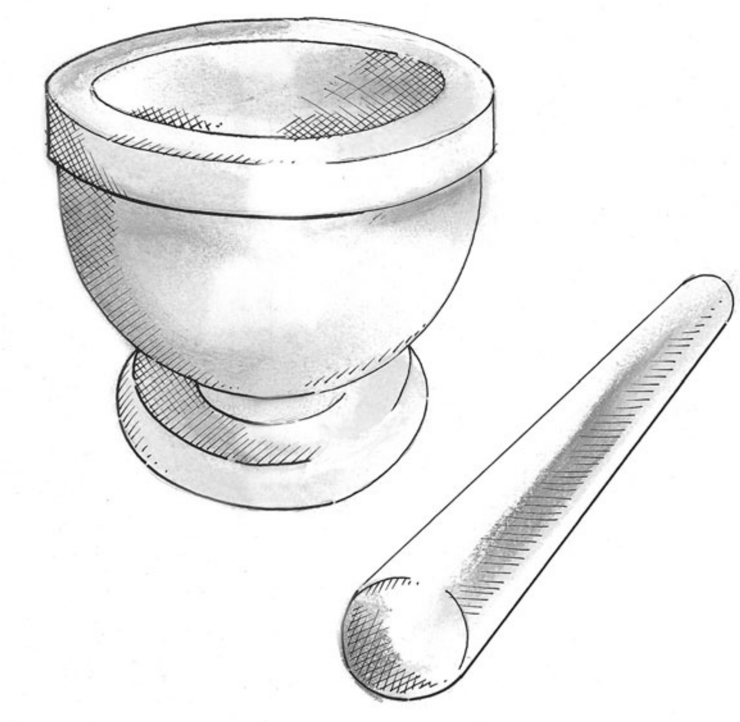
Colour Index Number	–
ASTM/BWS Rating	BWS 8
Common Names	–
Composition and Origin	Synthetic organic pigment.
Tinting Strength	Strong.
Shade	Deep red-brown.
Opacity	Transparent when expressed as a glaze.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	–
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

EARTH PIGMENTS

The production of pigment from earth deposits is of great value to many artists. Natural earth pigments tend to be irregular in terms of their particle size. This can mean that from one batch of pigment to another, there are discrepancies in terms of the exact colour and grind size. To the manufacturer of artists' paints, this can be something of a problem, because each time a pigment is prepared into paint, it needs to be checked against previous makings, and the formula may have to be adjusted accordingly. This can lead to extra costs and delays in processing. Also, natural earth pigments are not suited to the acrylic paint making process, due to inconsistencies in the particle size and the possibility of contamination/impurities being present. In oil paints and watercolours, this is less problematic, but in the case of acrylic, it may upset the balance of other raw ingredients used. Consequently, it is far simpler for a manufacturer to use modern synthetic iron oxides, which have regular particle sizes and tend to be consistent from batch to batch. However, the nuance of colour provided by synthetic iron oxides is different from that of the natural earth pigments. The synthetic iron oxides are strong and opaque by comparison. Natural earth pigments tend to be subtle in shade and create beautiful transparent glazes when diluted or when manipulated with the addition of a paint medium. The supply of earth pigments is another factor. The traditional core colours – raw sienna, burnt sienna, raw umber, burnt umber, green earth, venetian red – may not be derived from their original sources in the current market. In order to obtain natural earth pigments more cheaply, it may be necessary to look outside Western Europe. In any case, the processing of natural earth pigments may be less thorough than in previous times.

Just as the mineral pigments produced from semi-precious stones have to be worked in a specific manner to gain the best colour, so the processing of earth deposits involves considerable work. The raw material needs to be washed and freed from impurities such as plant debris. It can then be dried, pulverised and sieved through a fine mesh to gain particular grind sizes.

In the UK, the author has recently visited a producer of ochre pigments in Gloucestershire, at Clearwell. This former iron mine has long been a source for yellow, orange, red and purple ochre pigments. Indeed, the term "English Red" is often cited as having originated from Clearwell, in the Forest of Dean. Today, the mine is effectively a part of the heritage industry. Guided tours can be made underground, with exhibits of mining equipment and an explanation of the geology of the area. In the old mine workings, small pockets of ochre are still found and are sold by the company through their own on-site shop, in small quantities. Although such deposits could never be used in a manufacturing context, to an individual artist, familiar with the preparation of pigment into binding media, such colours have a special nature and significance. Another example of English ochre was that dug from open pits in Oxfordshire (Shotover Hill near Oxford). This colour is referred to as "oxford ochre" and is a particularly orange cast.



Pestle and Mortar

Examples of Earth Pigment Deposits

Limonite – Cyprus

The term limonite can be ascribed to all forms of hydrated ferric oxide (natural oxides of iron). In terms of clarity of colour and paleness, limonite deposits in Cyprus have always been highly prized.

French ochres – Rousillon, Le Luberon, France

A rich variety of natural ochres in yellow, orange and red shades. These ochres are washed, sieved and levigated in the traditional manner to produce the best quality colour, free of impurities.

English red – Clearwell Caves, Gloucestershire, England

This ancient iron mine continues to yield very strong ochres in colours varying from yellow, orange and red to purple and brown. The colour is found in loose, clumpy powder form and is dug out from small cavities between sedimentary layers of limestone. It is first steeped in water to remove plant debris and other impurities. The pigment is then stirred and the finest particles, while in suspension in water, are floated off and left to dry out over a period of days. They are then pulverised to form a fine powder, suitable for paint making or for adding into lime mortars for house painting.

In industrial terms, english red relates to a form of synthetic iron oxide (PR 101), usually with a yellowish shade. However, true english red may refer back to any number of native red earths found in England, but perhaps most importantly those found within the Forest of Dean, at Clearwell Caves.

Raw sienna – Arcidosso, Tuscany, Italy

Prior to the 1930s, sienna was dug from open pits near the town of Arcidosso. The yellow earth was carefully washed and sieved to provide pigment of the strongest colour and optimum transparency. The raw product was calcined to create burnt sienna.

Sienna should always have a degree of transparency. It differs from ochres (which are milky, opaque) in that the clay base of raw sienna means that it has a high proportion of silica (which is translucent and affords good light refraction).

Haematite – "Ruddle" Florence Mine, Egremont, Cumbria, England

The west coast of Cumbria was once an important source of pig iron, used in the manufacture of steel. Rich iron ore seams (haematite) lie in between layers of limestone. Mining for iron ore in Cumbria dates back to Roman times but was developed industrially at the end of the 19th century, to serve the shipbuilding yards at Barrow-in-Furness. Florence mine was first worked in 1914 and at the height of production in 1924 was producing over 4,000 tons of pure grade haematite per week. Although the mining of iron ore is today much reduced, Florence mine is still producing iron oxide pigment for use in the paint and cosmetics trades, and the mine is also open to visitors, who can take a tour underground. The rich red haematite derived from Cumbria is known locally as "ruddle" and in former times was used for sheep-marking. It has a very strong red-violet shade, but the pulverised rock retains a little grittiness when hand-processed using a pestle and mortar.

Armenian Bole

$Al_2O_3.SiO_2+Fe_2O_3$.

By tradition, the soft, clay-rich red coloured ground applied below gilded surfaces is taken from a type of red earth from Armenia, and commonly referred to as armenian bole. This description, while perhaps not viable in the present market is still often applied, to denote that the pigment has a soft texture, suitable for binding with animal glue size as a ground for gold leaf. In practice, armenian bole may be used to describe any earth-tone pigment used for this purpose (PR 102), including artificially prepared iron oxides.

Brown Ochre (PY 43)

Dull, fawn ochres are often referred to in old manuals on painting practice as "brown ochre". The colour is derived from the natural product, although it is possible to calcine varieties of yellow ochre, or even green earth to provide similar soft brown shades.

Burnt Ochre

Any yellow or pale orange ochre, or other forms of PY 43 (e.g. raw sienna) can be calcined to give darker hues. This process, (as with burnt sienna) reduces the water-content of a pigment and makes the resultant colour slightly more transparent in nature. The author has deposited samples of various ochres into a kiln, heated to approximately 600°C, to gauge this colour change. It was observed that the strong yellow ochres from France turned a fiery orange-brown, while a sample of pale Italian brown ochre simply became a shade darker. See also: light red.

Burnt Green Earth, Veronese Brown (PG 23/C.I. 77009)

Fe, K, Mn, Al.

As with the ochres, samples of green earth, when calcined, transform to rich red-brown shades. These burnt green earths have great transparency and vary in shade according to the type of green earth used. It is vital that the calcined green earth be pure, rather than co-mixed with industrial pigments, which is often the case.

Caledonian Brown

A deep, rich red-brown, containing oxides and/or hydrates of iron and manganese, the latter giving good drying properties in oil. It usually contains some residual moisture and thus requires air-drying prior to use. By calcination, caledonian brown provides a deep black-brown shade. An imitation shade can be easily prepared by mixing burnt sienna with van dyke brown or burnt umber.

Cappagh Brown, Mineral Brown

The original source for cappagh brown was at Skibbereen, County Cork in Ireland, on the estate of Lord Audley, who began producing the pigment in 1814. When this original source was closed, the remaining stock was purchased by Winsor & Newton, from whom it was still available in 1925. The high manganese content of the original pigment made this a fast-drying colour when prepared as oil paint. It is a similar red-brown shade to caledonian brown but may contain trace elements of humus (decomposed plant matter, peat). Prior to use, the pigment is required to be air-dried to become free of moisture.

Davy's Grey (PBk 19)

Powdered slate, sometimes including portions of soft clay in powdered form, provides a variety of soft, warmish grey, blue-grey and green-grey pigments, which can be used with care in strong water-based binders such as casein. As oil colour, the finer grades of davy's grey make excellent neutral tones when admixed to transparent colours, providing tints towards darkness, due in part to the pigment's weak tinting strength and good transparency. In oil, davy's grey dries fast and evenly. Some dry pigment samples can have an uneven texture, due to inclusions of impurities and may therefore be difficult to process. Pulverisation in a pestle and mortar of the dry pigment can help to free any clumping of particles and reduce grittiness. It may also be advisable to leave the dry pigment to air, so that it loses a little residual moisture, prior to use with oil binders.

Manufactured oil and watercolour paints can include examples of davy's greys formed from admixtures of other pigments. The colour is named after artist Henry Davy (1780-1833), who recommended its use to the colourmaker Winsor and Newton.

In watercolour, "neutral tint" can be prepared by mixing davy's grey with red ochre and ultramarine. An earlier (and more fugitive) formula for neutral tint was derived from carmine, lamp black and indigo.

Gulf Red, Persian Red Oxide (PR 102)

Red earth pigments are found all over the world, but can vary widely in terms of texture and colour. The red native earths of the Persian Gulf have a hard texture, similar to that of a mineral pigment (i.e. crystalline) and tend to contain almost 100% pure iron oxide. As a consequence, the colour can be much heavier, tending towards violet, when compared to many European red earths.

Sinopia is another name commonly applied to any number of natural red earth pigments (originally from the ancient city of Sinope). In fresco painting, sinopia is the colour used to make the cartoon underdrawing. Cinabrese as a flesh-tint used in fresco painting, is composed of two-thirds sinopia to one-third bianco san giovanni.

Indian Red (PR 101)

Today, indian red refers to a shade of synthetic iron oxide, usually with a cold, blue-violet tinge. It is a by-product of other iron-related industries, produced from the calcination of ferrous sulphate. The native earth, imported to Britain in the 19th century would have contained over 90% pure red iron oxide, and possessed a similar violet tinge to the modern product.

Light Red (PR 102)

The modern product is a synthetic iron oxide red with a warm shade. The original pigment was prepared by heating selected yellow ochre, the colour being arrived at according to the heat applied and the colour of the original ochre material.

Pompeii Red (PR 102)

The name refers to the pigment of antiquity from Pompeii, being an orange-red earth pigment, with a degree of transparency as a glaze. As with other similar red earths, the low colour strength is due to the ratio of iron oxide to clay. The modern product may be based on a mixture of red earth pigments and may or may not contain artificial iron oxides.

Pozzuoli Red

True pozzuoli red is a soft, delicate red from volcanic earth deposits and was processed, through pulverisation and washing, at Pozzuoli in the Bay of Naples until the 1930s. As with pompeii red, the modern product may be based on a mixture of red earth pigments and may or may not contain artificial iron oxides. Pozzuolana earth may refer to a pale natural earth still produced at Pozzuoli, but which contains a high proportion of silica and is used for its natural, fast-setting, cement-like properties in building restoration.

True native red earths are intrinsically linked to volcanic activity, the coloration caused when yellow-orange iron bearing rock and earth is exposed to intense heat from active volcanoes.

Spanish Red (PR 102)

An old colour name, spanish red refers to soft orange-red ochre pigments, from Castille in Spain.

Terra Rosa (PR 101)

An old trade name for a natural red earth pigment from Italy, similar in shade to venetian red (pinkish).

Turkey Umber, Turkey Brown (PBr 7)

Turkey umber is raw umber, whose deposits were originally those in Cyprus or the Turkish Mediterranean region.

Venetian Red (PR 101)

Venetian red in its original form is a partially hydrated natural iron oxide with a characteristic pinkish shade, especially when admixed with whites. When used with animal skin glue in combination with chalk in a dilute consistency, it makes a fine, translucent pink ground colour over gesso.

The modern product is manufactured by calcination of ferrous sulphate with chalk (calcium carbonate). The proportion of colour to chalk varies from source to source, but is typically somewhere in the region of 20-30% iron oxide to 70-80% calcium carbonate, thus giving a relatively weak tinting strength with a pinkish hue – less brown than with light red, and less violet when compared to indian red.

"Neutral orange" is an old Winsor & Newton colour name for a preparation of venetian red with cadmium yellow.

RAW UMBER PBr 7

Colour Index Number	77492
ASTM/BWS Rating	ASTM I
Common Names	Cyprus umber, turkey umber, green umber.
Composition and Origin	$Fe_2O_3.MnO_2.nH_2O+Si+al_2O_3$. Natural earth pigment, derived from natural iron oxide ore, with varying amounts of manganese and aluminium silicate.
Tinting Strength	Good.
Shade	From yellow-brown and green-brown to olive-brown, can be cool to warm in tone.
Opacity	Deeper shades more transparent.
Suitability to Media	Stable to all media but may be difficult to disperse into acrylic binders.
Drying Rate (in oil)	Fast. Strong catalytic effect, use in admixtures during underpainting and for toned grounds.
Defects	Rapid drying can cause cracking if applied over slower drying colours. Darkens with age.
Availability/Cost	Inexpensive, widely used.
Comments	Useful for underpainting. Because it darkens appreciably in oil, use carefully. Requires high oil content (up to 80%) – may absorb oil from subsequent paint layers if overpainted when wet.
Special Note	–
Health & Safety Information	–

BURNT UMBER PBr 7

Colour Index Number	77492
ASTM/BWS Rating	ASTM I
Common Names	Brown iron oxide.
Composition and Origin	$Fe_2O_3.MnO_2.nH_2O + Si + Al_2O_3$. Natural burnt earth pigment. Calcined raw umber.
Tinting Strength	Good.
Shade	Variety of shades, from red-brown to dark brown, generally with a stronger, warmer tone than raw umber.
Opacity	Fairly transparent, more transparent than raw umber.
Suitability to Media	Stable to all media but may be difficult to disperse into acrylic binders.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Inexpensive, widely available. Often used in mixtures with other reliable pigments to give imitations of unreliable antique colours such as van dyke brown.
Comments	–
Special Note	–
Health & Safety Information	–

RAW SIENNA PBr 7

Colour Index Number	77492
ASTM/BWS Rating	ASTM I
Common Names	Sienna, natural sienna, raw sienna.
Composition and Origin	$Fe_2O_3.nH_2O$ + Mno_2 + $Al_2O_3.SiO_2.2(H_2O)$. Natural earth pigment, a mixture of iron oxide and silica. Known since antiquity.
Tinting Strength	Good.
Shade	Warm, deep golden yellow, darker than yellow ochre due to higher silica content. Although dark as a mass tone, raw sienna brushes out to a bright transparent yellow.
Opacity	Tends towards transparent.
Suitability to Media	Stable to all media but may be difficult to disperse into acrylic binders.
Drying Rate (in oil)	Fast to medium.
Defects	High oil absorption, tends to darken when ground in oil.
Availability/Cost	Inexpensive, widely used.
Comments	–
Special Note	–
Health & Safety Information	–

BURNT SIENNA PBr 7

Colour Index Number	77492
ASTM/BWS Rating	ASTM I
Common Names	Burnt sienna.
Composition and Origin	$Fe_2O_3.nH_2O + al_2O_3$. Calcined raw sienna. Burnt sienna and other calcined natural earths are thought to date back to antiquity.
Tinting Strength	Good.
Shade	Deep and bright red-brown.
Opacity	Very good glazing colour.
Suitability to Media	Stable to all media but may be difficult to disperse into acrylic binders.
Drying Rate (in oil)	Fast-Medium.
Defects	Darkens with age in oil, may harden when ground with poppy oil.
Availability/Cost	Inexpensive, widely used.
Comments	–
Special Note	–
Health & Safety Information	–

VAN DYKE BROWN Natural Brown 8 or PBr 9

Colour Index Number	PBr 9/77430
ASTM/BWS Rating	Not tested.
Common Names	Cassel brown, cologne earth (usually a calcined form of van dyke brown).
Composition and Origin	$Fe_2O_3.nH_2O$. Where manganese deposits are found in brown coal (lignite), a brown pigment, commonly known as van dyke brown is formed. It is still of interest to painters because of its excellent transparency: when mulled into linseed oil, it gives a deep black-brown colour, that can be drawn out to a thin glaze. However, van dyke brown never completely dries successfully, tending to remain in a semi-soluble state as a paint film. Although it contains some manganese, it is a very poor drier in oil, tending to slow down the formation of a closed paint film indefinitely. Where the pigment is used in water-based binders, or when underbound in oil-based paints, it has a tendency to turn greyish upon exposure to air. When mixed in small quantities into an oil-resin medium, it is less problematic and slightly more stable over time.
Tinting Strength	–
Shade	In oil, a deep brown-black, sometimes with a warm shade. In watercolour, has a slight violet-brown tinge.
Opacity	Transparent in all media, but shows a slight graininess in water-based binders.
Suitability to Media	Unsuitable in all media. In oil, it dries very poorly, often causing cracking and wrinkling of the paint film. In water-based techniques, it turns grey on exposure to air.
Drying Rate (in oil)	Slow – never completely dries.
Defects	Instability to light in water-based media and poor-drying characteristics in oil make this pigment unsuitable for all media.
Availability/Cost	Inexpensive, rarely found in modern paint ranges. Substitute with mixtures of burnt umber with blacks for stable alternative.

Comments	When van dyke brown is added in very small quantities to a glaze medium, it can be used for final coatings in oil painting, with some success.
Special Note	–
Health & Safety Information	–

YELLOW OCHRE PY 42, PY 43

Colour Index Number	77492
ASTM/BWS Rating	ASTM I
Common Names	Gold ochre, light ochre, roman ochre, brown ochre, also calcined variety, burnt ochre, a red-brown, similar to burnt sienna.
Composition and Origin	$Fe_2O_3 . x H_2O$. A natural earth pigment, varying in shade according to source. Formed by the coloration of silicate (clay) and/or calcium carbonate (chalk) by iron oxide, in conjunction with water. Found on cave, rock, wood support paintings dating back to antiquity.
Tinting Strength	Varies according to source, generally paler than raw sienna but less transparent.
Shade	Pale, warm yellow: other ochres available in shades from yellow, through orange and red to brown.
Opacity	Tends to be more opaque than sienna.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Medium to slow.
Defects	High oil absorption if the pigment contains large amounts of clay.
Availability/Cost	Inexpensive, widely used, on a small scale there is a continuing supply from original sources (e.g. Rousillon, France).
Comments	Ochre with more clay content will be softer in texture than ochre containing a larger proportion of chalk.
Special Note	–
Health & Safety Information	–

GREEN EARTH (Terre Verte) PG 23

Colour Index Number	77009
ASTM/BWS Rating	ASTM I
Common Names	Terre verte, terra verde, verona green earth, bohemian green earth (often named according to source).
Composition and Origin	Fe, Mg, Al, K. A natural earth pigment, clay, coloured by iron silicate, containing glauconite and/or celadonite. Known since antiquity, offering different shades according to source. For example, the original shade of verona green, sourced at Bentonico, on Mt. Baldo, near Verona is a delicate, pale grey-green. By contrast, aegrine from Malawi is very dark in colour, and has a pronounced, needle-like structure, which is best preserved in casein or glue binders on to stiffish paper. Bohemian green earth, from the Czech Republic, is a brilliant pale green, similar to malachite. Green earth from Cyprus has a cool blue-green shade. Deposits are also found in the Baltic States and parts of Russia.
Tinting Strength	Low.
Shade	Cold, pale greenish-grey.
Opacity	Very transparent.
Suitability to Media	Stable to all media but may be difficult to incorporate into acrylic binders due to inclusion of impurities. In lime-fresco, avoid mixed green earths containing small quantities of prussian blue.
Drying Rate (in oil)	Medium to slow. Forms a very soft paint film, especially when applied with any impasto.
Defects	High oil content (up to 100%), darkens with age.
Availability/Cost	Inexpensive, widely available, although the "original" grades, such as bohemian and verona green earth are more expensive.
Comments	Best applied in thinned glazes.
Special Note	When calcined, green earth gives a red-brown colour with some transparency, "burnt green earth".
Health & Safety Information	–

SYNTHETIC IRON OXIDES

MARS COLOURS (Synthetic Iron Oxides) (shades)
YELLOW PY 42/C.I. 77492
ORANGE PY 42/C.I. 77492
RED PR 101/C.I. 77491
RED PR 102/C.I. 77492
VIOLET PR 101/C.I. 77015
BROWN PBr 6/C.I. 77499
BLACK PBk 11/C.I. 77499

Colour Index Number	PY 42, PR 102/77492, RED PR 101/77491, VIOLET PR 101/77015, PBr 6, PBk 11/77499
ASTM/BWS Rating	ASTM I
Common Names	Mars yellow, mars orange, mars red, mars violet (caput mortuum red, or caput mortuum violet), mars brown, mars black, light red, venetian red (true venetian red has long been replaced with synthetic iron oxide). Colcothar is an old term for mars red.
Composition and Origin	Fe_2O_3. A group of artificial mineral pigments, hydrated ferric oxides, which effectively replace in terms of performance some of the natural earth pigments. Derived from the oxidation of metallic iron, or iron salts. Commercial manufacture dates from the mid-1800s.
Tinting Strength	Strong.
Shade	Yellow, orange, red, red-purple earth shades, plus brown and black.
Opacity	Good.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Medium.
Defects	Often deemed too opaque when compared to natural earth pigments.
Availability/Cost	Inexpensive, widely used.

Comments	Alternative to natural earths, free of impurities. Many brands also now include a range of transparent iron oxides, which are luminous and bright. Mars black is a useful and cheap alternative to other black pigments, being opaque and therefore possible to use in mild impasto oil paint applications, without undue shrinkage upon drying.
Special Note	–
Health & Safety Information	–

TRANSPARENT IRON OXIDE (shades)
YELLOW PY 42/C.I. 77492
ORANGE PY 42 PR 101/C.I. 77492-77491
ORANGE-RED PR 102/C.I. 77492
RED PR 101/C.I. 77492

Colour Index Number	YELLOW PY 42, ORANGE-RED PR 102, RED PR 101/77492, ORANGE PY 42 PR 101/77492-77491
ASTM/BWS Rating	ASTM I
Common Names	Transoxide red, yellow, etc; translucent iron oxide red, yellow, etc.
Composition and Origin	A special class of synthetic iron oxide, where the pigment particle shape is altered (micronised) so that more light transmits through the paint film. The resulting colour is similar in transparency to the natural earths raw sienna and burnt sienna, but with a more glowing intensity.
Tinting Strength	Strong.
Shade	Yellow, orange, orange-red, red.
Opacity	Very transparent, or rather translucent.
Suitability to Media	–
Drying Rate (in oil)	Medium.
Defects	Over-strong when compared to transparent natural earth pigments, thereby lacking subtlety.
Availability/Cost	Available as pigment and in many updated oil colour ranges. Some ranges use transparent iron oxides to replace similar natural earths, such as burnt sienna.
Comments	The transparent iron oxides are luminous and bright and make ideal glazing colours. They appear dull and grainy in dry pigment form, but once worked into oil, they become clear, bright, translucent and warm in tone.
Special Note	–
Health & Safety Information	–

SPINEL PHASE PIGMENTS (shades)
BROWN LIGHT PY 119
BROWN DARK PY 119
BLACK-BROWN PG 17

Colour Index Number	PY 119/77496, PG17/77288
ASTM/BWS Rating	Not tested.
Common Names	Zinc iron brown light, zinc iron brown dark, zinc iron chrome brown light, haematite-chrome oxide black-brown.
Composition and Origin	Spinel pigments are man-made minerals, manufactured by calcining an intimate mixture of metal oxides at high temperatures. During this process a compound is formed with its own chemical structure. The desired colour is produced by selecting specific metals such as chrome, nickel, antimony, titan, manganese, cobalt, aluminium, zinc, iron, copper, etc. The compound is then ground to particle size.
Tinting Strength	Good.
Shade	Shades of brown, similar to the iron oxides but with more warmth and subtlety of colour.
Opacity	Good.
Suitability to Media	–
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	–
Comments	A new choice of strong colours, perfect for application in oil painting.
Special Note	–
Health & Safety Information	–

BLUE PIGMENTS

PHTHALOCYANINE BLUE PB 15/C.I. 74160 METAL FREE PB 16/C.I. 74100

Colour Index Number	PB 15/74160, PB 16/74100
ASTM/BWS Rating	ASTM I
Common Names	Heliogen blue, monestial blue, monastral blue, thalo blue.
Composition and Origin	$C_{32}H_{16}CuN_8$ = PB 15, $C_{32}H_{18}N_8$ = PB 16. A synthetic organic pigment, copper phthalocyanine. Invented in 1928 and introduced to the market in the 1930s.
Tinting Strength	Very high.
Shade	Very bright, intense deep blue, lighter than prussian blue, available in various shades (e.g. blue shade, green shade, red shade, etc).
Opacity	Very transparent but covers well.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Medium to slow.
Defects	Difficult to wet: prepare a paste with white spirit before grinding with oil.
Availability/Cost	Widely used, often to imitate cobalt or cerulean, in mixes with white and phthalocyanine green.
Comments	A high tinting strength colour, often reduced in power with additions of blanc fix or aluminium hydrate to meet the hue of traditional pigments. When used at full strength, the dried paint film may show a bronze-copper sheen, especially in water-based paint systems.
Special Note	Requires wetting agent.
Health & Safety Information	Contains copper, very fine particles tend to stain skin and clothing. Always wear a dust mask and gloves when handling pigment, or when applying paint.

PRUSSIAN BLUE PB 27

Colour Index Number	77510
ASTM/BWS Rating	ASTM I
Common Names	Milori blue (softest powder, easiest to hand-grind), berlin blue, paris blue, chinese blue, iron blue.
Composition and Origin	$Fe_4(Fe[CN]_6)^3$. Artificial inorganic pigment, based on ferric chloride and potassium ferrocyanide (ferric ferrocyanide). Discovered by accident in Berlin, in 1704 and subsequently introduced as an artists' pigment.
Tinting Strength	Very high.
Shade	Bluish-black in mass tone.
Opacity	Very transparent, ideal glazing colour.
Suitability to Media	Darkens in oil, sensitive to alkalis and therefore never used in fresco.
Drying Rate (in oil)	Fast: wrinkles when applied thickly.
Defects	Sensitive to alkalis. It is never used in the preparation of acrylic colours, where it would react with the alkaline nature of acrylic resin binders. In acrylic paint ranges, a hue replacement for prussian blue can be prepared by mixing phthalocyanine blue with a small addition of lamp/carbon black. Prussian blue may darken in tone when finished paintings are stored away from light. Can turn brown as oil paint. In watercolour, it can fade when admixed with a large percentage of zinc white.
Availability/Cost	Inexpensive, widely used.
Comments	Good mixing colour: a little goes far.
Special Note	Requires wetting agent. "Hooker's green" is an old colour name that usually refers to a mixture of prussian blue with natural gamboge, presented as a watercolour paint. On exposure to light, the gamboge fades somewhat, leaving a blue cast to the paint layers. Old watercolours may show this defect. In some cases, natural gamboge

	is mixed with indigo, where both colours fade to an extent when exposed to light. Modern paints that include hooker's green tend to be prepared from mixtures of prussian blue (or phthalocyanine blue) with a permanent type of synthetic organic yellow, or with a cadmium yellow. Sometimes, the less permanent nitroso green pigment is used for hooker's green. "Prussian green" usually denotes a mixed colour, formerly prepared with (fugitive) natural gamboge or stil di grain, with prussian blue. Modern preparations of this colour tend to include mixtures of prussian (or phthalocyanine blue) with synthetic organic yellows. "Antwerp blue" is a weaker tint of prussian blue, containing aluminium hydrate, as is "brunswick blue". "Brunswick green" is a co-mixture of brunswick blue with chrome yellow. "Cinnabar green" is a co-mixture of chrome yellow deep, prussian blue and raw sienna. Updated paint ranges featuring cinnabar green tend to replace chrome yellow with a synthetic organic yellow, such as hansa yellow (PY 3). "Cyanine blue" as oil colour usually refers to a combination of prussian blue with cobalt blue. Another name for this mixture is "leitch's blue". "Prussian green" as oil colour was formerly based on a mixture of prussian blue with either zinc yellow or chrome yellow. Later mixtures tend to be based on prussian blue with a synthetic organic yellow, such as hansa yellow (PY 1).
Health & Safety Information	Very high tinting strength, tends to stain skin and clothing. Wear gloves and a mask when using pigment or paints.

COBALT BLUE PB 28

Colour Index Number	77346
ASTM/BWS Rating	ASTM I
Common Names	Thenard's blue.
Composition and Origin	$CoAl_2O_4$. An artificial mineral pigment, derived from calcined cobalt oxide and aluminium oxide (cobalt aluminate). Discovered in the 1770s but developed by Thenard commercially, from 1804.
Tinting Strength	Weak.
Shade	Light to deep varieties.
Opacity	Good transparency, when expressed as a glaze.
Suitability to Media	Stable in all media, very lightfast.
Drying Rate (in oil)	Fast.
Defects	Delicate blues yellow significantly in linseed oil. Cobalt blue performs better when ground in paler but slower-drying poppy oil.
Availability/Cost	Relatively expensive, widely used.
Comments	–
Special Note	–
Health & Safety Information	–

LAPIS LAZULI PB 29 (from semi-precious stone)

Colour Index Number	77007
ASTM/BWS Rating	Not tested.
Common Names	Natural ultramarine (oltremare – Italian, "from over the seas").
Composition and Origin	$3Na_{20}.3Al_{2}.6SiO_{2}.{}_{2}Na_{2}S$. Natural ultramarine, in pigment form, is derived from the semi-precious stone, lapis lazuli. The stone is composed of the blue mineral, lazurite, with additions of calcspar and iron pyrite. The original source for lapis lazuli lies in the valley of the Kokcha river, at Sar-e-sang (place of stones) in the province of Badakshan, north-eastern Afghanistan. These lapis mines were mentioned by Marco Polo in 1271, who noted that the stones were processed to make colour. Lapis lazuli from Afghanistan was imported into Europe through Venice, the main trading port between Europe and the East. While azurite had a dominant role in the development of painting in northern Europe, in the south and especially in Italy, lapis lazuli was extensively used through the Renaissance and during the golden period of Venetian painting in the 1600s. Lapis is today still mined by hand, and the stones that are brought to the surface are sorted into three basic qualities: "*rang-i-ob*" (colour of water); "*rang-i-sabz*" (green colour) and "*surpar*" (red feather). Surpar is considered the highest quality blue stone and has a deep blue-violet colour. The pigment is extracted from the stones by means of a complex process. After pulverisation, the resultant powder is mixed with a combination of molten wax, resin and oil. This mass compound is then wrapped in muslin cloth and immersed in a bath of lye (provided by wood ashes, potash, dissolved in water). The compound is kneaded under the surface of the water (which is in turn hot), whereby the blue particles of lazurite mineral are washed out from the compound. The particles settle out at the bottom of the vat: the water

	is then poured off and the particles are allowed to dry out thoroughly. The compound is washed a number of times in this manner, until almost no blue particles are left. The final washings produce a soft blue-grey colour, known as "ultramarine ash", which contains a high proportion of non-coloured particles. If the original stone is simply crushed to a fine powder and used as a pigment it will have a similar faint, blue-grey tinge. Poorer quality stones were formerly used to make a pale blue-grey with translucent properties, known as "mineral grey".
Tinting Strength	All mineral-based pigments are low in tinting strength, because when admixed with other colours, they lose their influence.
Shade	Best grades (often referred to as fra angelico blue) show a deep, blue-violet tinge.
Opacity	Good transparency, especially in oil glazes.
Suitability to Media	In water-based media (glue, gum arabic, egg), the true blue colour is beautifully shown. In oil, the colour is a deeper blue-violet. Often found in oil paintings as a thin glaze over an azurite or ultramarine ash underpaint. In oil, a small addition of lead white will provide a more covering, solid blue.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Expensive, although a new source in Chile has provided a reliable alternative to the Afghanistan variety, at a slightly lower cost.
Comments	Often employed with red lake pigments such as carmine or madder, to gain purple/violet mixtures. Also possible to lay down lapis as an underpaint, then overpaint with transparent glaze of red lake to gain purple/violet.
Special Note	Ask to see samples of pigment prior to purchase to ensure the colour strength and particle size is that required.
Health & Safety Information	–

ULTRAMARINE BLUE (shades)
BLUE PB 29/C.I. 77007 - $Na_{6\text{-}8}Al_6Si_6O_{24}S_{2\text{-}4}$
RED PV 15/C.I. 77007 - $H_2Na_{(4\text{-}6)}Al_6Si_6O_{24}S_2$
VIOLET PV 15/C.I. 77007 - $H_2Na_{(4\text{-}6)}Al_6Si_6O_{24}S_2$

Colour Index Number	PB 29, PV 15/77007
ASTM/BWS Rating	ASTM I
Common Names	French ultramarine, synthetic ultramarine, ultramarine red/pink (violet), ultramarine violet (available in three or more shades of violet), see also ultramarine green.
Composition and Origin	An artificial mineral pigment, made by heating clay, soda, sulphur and coal (sodium aluminium silicate-polysulphide). Commercially produced in France and Germany from the 1830s onwards, replacing natural ultramarine, lapis lazuli.
Tinting Strength	High.
Shade	Deep blue, grades from green-blue to red-violet.
Opacity	Transparent. Glazing pigment.
Suitability to Media	Stable in most media, but sensitive to alkalis, especially in lime-fresco. Some qualities of ultramarine blue are now prepared and sold as being stable to lime.
Drying Rate (in oil)	Medium to slow.
Defects	Difficult to grind by hand into a stable consistency. Add 2% wax or a stabilising additive such as aluminium stearate.
Availability/Cost	Inexpensive blue, widely used. A fraction of the price of lapis lazuli and much more intense.
Comments	Does not keep well when hand-ground and placed in collapsible tubes, tending to harden or revert to a stringy consistency.
Special Note	"New blue" is a pale variety of ultramarine, formerly prepared at Backbarrow, on the River Leven in the Lake District of England. The plant was known by the locals as the "Blue Factory", as all the buildings in the village were coated in blue, as were the trees and rocks. A recent visit (2001) found the site reused as a tourist hotel, no trace of blue remaining.

	"Payne's grey", as an oil colour or watercolour is usually prepared by combining ultramarine blue with lamp black, davy's grey and iron oxide red. The name relates to the English artist and lecturer William Payne (1760-1830), who passed on this mixing formula to many students and fellow artists.
Health & Safety Information	–

AZURITE PB 30

Colour Index Number	77420
ASTM/BWS Rating	Not tested.
Common Names	Copper blue, blue malachite, chessylite, mineral blue, mountain blue.
Composition and Origin	$2CuCO_3,Cu(OH)^2$. A basic copper carbonate, formed naturally within copper ore, often found in association with green malachite, another copper carbonate mineral. Azurite can be found in many parts of the world: early European sources of this pigment were located in the south of Germany, Hungary, Czech Republic, France and the Austrian Tyrol. It is likely that azurite was important within the context of Egyptian painting, but also in the tradition of wall painting in central Asia. It has been widely used in Japanese painting. The pigment is processed from the stone mineral by pulverisation, washing, levigation and sieving. The various particle sizes after pulverisation are separated from large to small, through sieving. The larger particles have the strongest colour. The more that the particles are crushed, the paler the colour becomes. Consequently, the large particle size format of this pigment, giving a strong blue, blue-green colour is most commonly used, despite its granular appearance.
Tinting Strength	Very weak: when admixed with other colours, it becomes insignificant within the mixture. A small amount (perhaps 5%) lead white, or zinc white admixed with azurite will give a reasonable pale blue, where the small white pigment particles close in between the larger azurite particles, so forming a more or less even paint film.
Shade	Dark blue, or blue-green, with crystalline structure.
Opacity	Slightly transparent.

Suitability to Media	For watercolour, bind with gum arabic solution; into tempera, use egg white, or apply in very thin films with egg yolk (to reduce the yellowing effect of the egg yolk); stable in casein, glue. Not stable in lime, unless mixed and used immediately. In oil, the acidity of the oil binder discolours the azurite, showing as a dirty green-blue. If the individual pigment particles are coated in protein (e.g. egg yolk), then dried and re-crushed to a powder, the resultant coated particles can be ground in oil without change. Azurite can change colour to green, reverting to malachite, when exposed to damp or humidity. This is especially poignant in water-based mediums that remain hygroscopic (e.g. rabbit glue). When incorporated into a thin glaze medium, azurite can be used as a final coating over dried oil paint. In historical paint technique, azurite is often found in tempera underpaintings, which may be overpainted with lapis lazuli.
Drying Rate (in oil)	–
Defects	Tendency to turn green when exposed to prolonged damp.
Availability/Cost	Expensive, available only in dry pigment form, in a variety of grind sizes. The paler shades equate to the smallest particle sizes.
Comments	–
Special Note	–
Health & Safety Information	–

EGYPTIAN BLUE PB 31

Colour Index Number	77437
ASTM/BWS Rating	Not tested.
Common Names	Copper silicate blue, blue frit, pompeiian blue, pozzuoli blue (the Egyptian process for making egyptian blue was brought to Italy through the port of Pozzuoli, according to Vitruvius).
Composition and Origin	$CaCuSi4O_{10}$. Derived from quartz, which is boiled together with copper and calcium at high temperatures (up to 1000°C). An artificially made pigment, dating from antiquity, egyptian blue was known through the Egyptian and Roman dynasties and into the middle ages. As a glass frit, egyptian blue is absolutely stable, as witnessed by its use and preservation on many Egyptian artefacts and wall paintings. Egyptian blue is a synthesis of the naturally occurring rare mineral cuprorivaite.
Tinting Strength	Weak, especially when admixed with other colours.
Shade	The exact shade of egyptian blue depends on the grind size of the particle: smaller particles tend towards pale, whitish blue, whereas the larger particles reveal a striking blue colour, similar to modern cobalt blue light or cerulean blue.
Opacity	Transparent, especially in oil glazes.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Now revived as a dry pigment but also available in a variety of shades as a glass pigment, the colour shade governed by the grind size of the particle (small particle size is very pale).
Comments	–
Special Note	–
Health & Safety Information	–

SMALT PB 32

Colour Index Number	77365
ASTM/BWS Rating	Not tested.
Common Names	Saxon blue, royal blue.
Composition and Origin	K,Co (Al) – potash silicate (glass) with cobalt oxide. Blue glass powder, a form of cobalt silicate. When cobalt salts are heated to a temperature of 1150°C, they melt to form a blue glass with a deep blue-black colour. The glass is quenched in water and pulverised to form a fine powder. Smalt dates from the 1500s, when sources of cobaltite and smaltite minerals were located in Saxony and Bohemia. Glass-makers took these minerals and found that, when heated to high temperatures, they could be used to colour glass blue. Smalt is also associated with the glass-makers of Murano, Venice and was used in many Venetian paintings during the 1600s, most often admixed with lead white, to create sky colours.
Tinting Strength	Weak when admixed with other colours; the transparency of the material causes it virtually to disappear. Best used alone, in thin oil glazes, so preserving the strong blue colour.
Shade	Deep blue with a purple tinge.
Opacity	Transparent. Glass.
Suitability to Media	Works best in water-based media. In oil, the blue colour becomes almost invisible: glass has a similar refractive index to dried linseed oil, as a consequence the eye does not register the colour. This phenomenon is only observed in dried paint films: when the paint is freshly applied, the blue colour remains visible. This effect can be countered by admixing smalt with a little lead white, which breaks up the way that light transmits within the paint film.
Drying Rate (in oil)	Very fast. Smalt has a catalytic effect on oil, indeed it has often been cited as a siccative agent for drying vegetable oils.
Defects	Can turn grey or pale on exposure to air.

Availability/Cost	Available in various grind sizes as a dry pigment. Best used when made up into a paint film, then applied. The large particle size tends to settle out, especially in water-based media, if left to stand for a long period.
Comments	–
Special Note	–
Health & Safety Information	–

MANGANESE BLUE PB 33

Colour Index Number	77112
ASTM/BWS Rating	ASTM I
Common Names	Manganese-cerulean blue.
Composition and Origin	$BaMnO_4BaSO_4$. An artificial mineral pigment. Barium sulphate – permanganate. Introduced as an artists' colour in the 1930s. The pigment was widely used to colour cement and within the ceramics industry. The toxicity of manganese blue seems to have played a part in its downfall. Sadly, production (in Europe) of this valuable pigment ceased in the late 1980s.
Tinting Strength	Best used independently as a glaze.
Shade	Very bright, cold blue with a greenish cast.
Opacity	Transparent.
Suitability to Media	Stable in all media, but liable to settle out in water-based paint systems. However, this phenomenon in watercolour (referred to as "granulation"), can be pleasing.
Drying Rate (in oil)	Fast.
Defects	Heavy, tends to settle out in mixtures, especially water-based paint-pastes.
Availability/Cost	No longer manufactured but may still be available through specialist art suppliers. Until recently, this brilliant, lightfast blue pigment was relatively cheap to buy. Although some suppliers still have stocks, the cost of the pigment has obviously increased since its manufacture ceased. Currently still found in some oil colour ranges.

Comments	A valuable pigment, of great interest to artists. Imitations of manganese blue, derived from mixtures between phthalocyanine blue and zinc white have recently come on to the market. They lack the characteristic hue and granular texture of the original pigment. Additions of spar or quartz mica into water-based combinations of phthalocyanine blue and zinc white may help to imitate the surface qualities provided by manganese blue.
Special Note	"Manganese green" is simply a greenish shade of manganese blue, now obsolete. It was also known as cassel green.
Health & Safety Information	Contains barium, toxic.

CERULEAN BLUE PB 35

Colour Index Number	77368
ASTM/BWS Rating	ASTM I
Common Names	Coeruleum blue, cobalt-cerulean blue.
Composition and Origin	$CoO.n(SnO_2)$. An artificial mineral pigment, made by roasting cobalt sulphate, tin salts and silica (cobalt stannate). Originally introduced in 1821, although the pigment was not widely used until Rowney & Co. introduced the pigment under the name coeruleum blue, in 1860.
Tinting Strength	Weak.
Shade	Bright but weak greenish-blue.
Opacity	Semi-transparent, slightly less so than cobalt blue.
Suitability to Media	Stable to all media but may show a tendency towards green when milled with linseed oil, where the yellow of the oil takes precedence over this pale and delicate blue. Pale poppy oil can be used instead, the fast-drying properties of cerulean blue assist rapid film formation of poppy oil.
Drying Rate (in oil)	Medium.
Defects	–
Availability/Cost	Found in most paint ranges. Expensive.
Comments	Manganese-cerulean blue previously formed an inexpensive alternative to cobalt-cerulean blue. Sadly, production of manganese blue has now ceased and as a result, the pigment is very expensive or unobtainable.
Special Note	–
Health & Safety Information	–

COBALT TURQUOISE PB 36

Colour Index Number	77343
ASTM/BWS Rating	ASTM I
Common Names	Cobalt turquoise light/dark, cobalt blue greenish.
Composition and Origin	$Co(Al, Cr)_2O_4$. A group of artificial mineral pigments, associated with cobalt blue and cerulean blue. May be derived from fusions of cobalt-chrome-lithium-titanium- and/or zinc oxides.
Tinting Strength	Similar to cobalt blue. The high key of cobalt turquoise is perhaps best used independently from other colours.
Shade	A range of shades: bright blue-turquoise, deep blue-turquoise, deep blue/green-turquoise.
Opacity	Semi-transparent.
Suitability to Media	Stable in all media, but may show a tendency towards green when milled in linseed oil.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Available as pigment and in some oil colour ranges. Expensive.
Comments	Mixtures of phthalocyanine blue and green, with zinc white can produce similar shades, which are useful, if not as subtle.
Special Note	–
Health & Safety Information	–

INDANTHRONE BLUE PB 60

Colour Index Number	69800
ASTM/BWS Rating	ASTM I
Common Names	Paliogen blue, chromophtal blue, anthraquinone blue, indanthrene blue.
Composition and Origin	$C_{28}H_{14}N_2O_4$. Synthetic organic pigment. Introduced in the 1950s.
Tinting Strength	Good – not as strong as other synthetic organic pigments.
Shade	A warmer, paler alternative to prussian blue and synthetic indigo, with less tinting strength.
Opacity	Transparent.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Medium to slow.
Defects	–
Availability/Cost	Available as pigment and in some updated oil colour ranges.
Comments	A lightfast alternative to natural and synthetic indigo.
Special Note	Requires wetting agent.
Health & Safety Information	–

BLUE VERDITER

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Mountain blue, blue bice.
Composition and Origin	$CuO + nH_2O$. An artificial copper-calcium carbonate pigment, a synthetic version of azurite. In manufacture, copper nitrate is mixed with chalk, or precipitated from copper sulphate in solution, in combination with ammonia and lime paste. During preparation, if the temperature becomes too warm, a green shade develops (green verditer). The author has samples of various makings, showing colours from blue, through blue-green (turquoise) to green. In England, verditer pigments were formerly manufactured in Sheffield, Yorkshire. Blue verditer was important in wall decoration during the 1600s and 1700s and also used on a small scale in easel painting.
Tinting Strength	Weak.
Shade	Pale blue, similar to cerulean blue and pale forms of azurite.
Opacity	Slightly transparent.
Suitability to Media	Works best in water-based binders. In oil, the copper reacts with acidity in the oil and turns green (copper oleate).
Drying Rate (in oil)	–
Defects	Turns green in oil.
Availability/Cost	Available as a dry pigment. Recommended as a useful pigment when hand-making watercolours.
Comments	–
Special Note	"Bremen blue" is prepared from copper hydroxide with copper carbonate and has a blue or green-blue shade.
Health & Safety Information	–

INDIGO

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Woad (European version of indigo).
Composition and Origin	$C_{16}.H_{10}.N_2O_2$. A natural vegetable pigment, derived from the leaves of the Indian plant, *Indigofera tinctoria.* The leaves are immersed in water and left to ferment, then dried, oxidising to indigo. This residue is then washed, boiled in water, air-dried and formed into small cakes or lumps. The cake form is then pulverised to form a fine, but slightly grainy powder, which can be further ground as required. In Europe, the woad plant, *Isatis tinctoria*, was formerly used to prepare a similar colour, important in both textiles and paint technique. In France, this colour was known by the term "pastel". Imports to Europe from India began in the 1600s.
Tinting Strength	Good.
Shade	Deep blue-black.
Opacity	Transparent.
Suitability to Media	Historically, indigo has been used in oil and watercolour technique. However, because it fades on exposure to sunlight, it can be replaced by mixtures between prussian blue or phthalocyanine blue and various black pigments.
Drying Rate (in oil)	Dries slowly in oil, especially in fat applications.
Defects	Fades in sunlight. Historical mixtures between indigo and yellow pigments to provide green are common. However, where the indigo has been exposed to light, the blue component may fade from the mixture, changing the nature of the green. Where indigo is not exposed to prolonged sunlight (e.g. in a closed portfolio), its deep velvet blue hue is preserved. Destroyed by alkali or acid exposure.
Availability/Cost	No longer available as a ready-made paint, but available in pigment form.

Comments	A special form of indigo, "maya blue" is now available, where the particles are mingled with attapulgite (a fibrous clay), magnesium silicate, which partially inhibits the passage of light rays to the blue pigment. In this manner, the colour is preserved, or rather degrades at a slower rate than natural indigo. Synthetic indigo is a form of dye (Vat Dye number 1) and is chemically similar to natural indigo. $C_9H_7NO_4$. Synthetic indigo was developed and patented by Bayer in the 1890s. Synthetic indigo is fugitive to light, but enjoyed considerable popularity in the early decades of the 20th century, when the price of both natural and synthetic indigo reduced dramatically, due to the manufacturers of these rival colours entering a protracted trade conflict.
Special Note	Requires wetting agent.
Health & Safety Information	–

SODALITE

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	–
Composition and Origin	$Na_8Al_6Si_6O_{24}Cl_2$. A semi-precious stone, sodalite has a crystalline structure. Sodium-aluminium-silicate. Found among alkali-rich volcanic rocks such as phonolite. Related to lazurite (the blue colouring in lapis lazuli stones).
Tinting Strength	Weak.
Shade	Translucent, pale white-blue grainy powder.
Opacity	Transparent.
Suitability to Media	Best suited to strong protein binders such as casein on to stiff paper, where the translucent character of this subtle pale blue is preserved.
Drying Rate (in oil)	–
Defects	Only available in larger particle size (when ground finely, the colour is lost).
Availability/Cost	Expensive.
Comments	Use carefully on to gesso panel (with glair binder), or with casein on to stiff paper.
Special Note	–
Health & Safety Information	–

PURPURITE

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	–
Composition and Origin	Purpurite is a natural form of iron-manganese-phosphate. The pulverised stone has a crystalline structure, which has a slight glinting effect when bound in casein or glue. Paler varieties, from powdered slate coloured by iron and manganese (*cote d'azur* violet).
Tinting Strength	–
Shade	Similar to natural *caput mortuum*, a deep but bright purple.
Opacity	Slight transparency in glazes.
Suitability to Media	Useful in tempera and other water-based media.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Expensive, available as pigment only.
Comments	–
Special Note	–
Health & Safety Information	–

ALIZARIN VIOLET PV 5

Colour Index Number	58055
ASTM/BWS Rating	BWS 7-8
Common Names	Purple madder lake, alizarin purple.
Composition and Origin	Synthetic organic pigment. Dihydroxyanthraquinone: related to alizarin crimson. Can fade when admixed with white, or painted as glaze against pale ground. Some varieties can run (seep) in oil glazes.
Tinting Strength	Similar to alizarin crimson.
Shade	Deep red-violet with a cold edge.
Opacity	Good transparency.
Suitability to Media	–
Drying Rate (in oil)	Very slow.
Defects	Some varieties may bleed in oil. As with alizarin crimson, avoid using in thick layers to prevent paint film from wrinkling.
Availability/Cost	Available as pigment and in some oil colour ranges. Largely replaced by other synthetic pigments with better permanence.
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

COBALT VIOLET DEEP PV 14

Colour Index Number	77360
ASTM/BWS Rating	ASTM I
Common Names	Cobalt violet dark.
Composition and Origin	$Co_3(PO_4)^2$. An artificial mineral pigment. Anhydrous cobalt phosphate. Manufacturing process discovered in 1859. The pigment is slightly coarser than cobalt violet light but is stable and lightfast in oil.
Tinting Strength	Better than cobalt violet light.
Shade	Deep red-violet.
Opacity	More transparent than cobalt violet light.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Cobalt violet light and dark are offered in many paint ranges. Because the pigment is so expensive, the intensity of prepared colour ranges can vary widely, according to the amounts of extender added to the paint.
Comments	–
Special Note	–
Health & Safety Information	Contains cobalt.

MANGANESE VIOLET PV 16

Colour Index Number	77742
ASTM/BWS Rating	ASTM I
Common Names	Permanent violet, mineral violet.
Composition and Origin	$H_4O_7P_2.H_3n.Mn$. An artificial mineral pigment. Manganese dioxide-ammonium phosphate. Introduced as an artists' colour, 1890. Often overlooked, due to its poor tinting strength and dull character.
Tinting Strength	Weak, best used independently.
Shade	Dull, dark violet, with a reddish tinge.
Opacity	Semi-opaque.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Cheaper than cobalt violet, although not as intense or bright.
Comments	–
Special Note	In oil colour may sometimes include an addition of ultramarine blue, to give a bluish tinge.
Health & Safety Information	Contains manganese.

DIOXAZINE VIOLET (shades)
Red Shade PV 23 RS/C.I. 51319
Blue Shade PV 23 BS/C.I. 51319

Colour Index Number	51319
ASTM/BWS Rating	PV 23 RS – ASTM I, PV 23 BS – ASTM II
Common Names	Dioxazine purple, purple red, permanent violet.
Composition and Origin	$C_{34}H_{22}Cl_2N_4O_2$. Synthetic organic pigment. Carbazole dioxazine. The blue shade is more liable to some fading when mixed with white. Developed in Germany, dates from 1929.
Tinting Strength	Good.
Shade	Saturated, almost black as a powder. When mixed as a paint, thins to blue or red purple glaze, according to shade.
Opacity	Good transparency.
Suitability to Media	Stable to all media – permanence to light reduced in strong admixtures with white.
Drying Rate (in oil)	Slow-Medium.
Defects	–
Availability/Cost	Common in many modern oil colour ranges, also as dry pigment. Expensive.
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

COBALT VIOLET LIGHT PV 47

Colour Index Number	77363
ASTM/BWS Rating	Not tested.
Common Names	Cobalt violet pale.
Composition and Origin	An artificial mineral pigment. Calcined cobalt arsenate (therefore toxic). Dates from the early 1900s. The particular hue of cobalt violet light cannot be matched through mixing other colours. Despite the high price, it is still an important colour for artists. Cobalt violet light has a tendency to darken slightly when ground as an oil colour (due to high oil absorption).
Tinting Strength	Weak.
Shade	Pale violet.
Opacity	Semi-opaque.
Suitability to Media	Stable in oil and watercolour. Not usually prepared as acrylic colour, as the pigment tends to settle out in aqueous mixtures.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Expensive, although common to most paint ranges.
Comments	Weak tinting strength – best used alone, or carefully mixed down with zinc white.
Special Note	–
Health & Safety Information	Contains cobalt-arsenate. Toxic.

COBALT VIOLET LIGHT (BRILLIANT) PV 49

Colour Index Number	77362
ASTM/BWS Rating	Not tested.
Common Names	Cobalt violet brilliant.
Composition and Origin	An artificial mineral pigment.
Tinting Strength	Weak.
Shade	Very bright, brilliant purple-violet. Brighter than PV 47.
Opacity	Semi-opaque.
Suitability to Media	Stable in oil and watercolour.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Expensive, available as dry pigment.
Comments	–
Special Note	–
Health & Safety Information	–

GREEN PIGMENTS

PHTHALOCYANINE GREEN PG 7, PG 36

Colour Index Number	74260 – PG 7 (green-blue shade) 74265 – PG 36 (brominated copper phthalocyanine – yellow shade)
ASTM/BWS Rating	ASTM I
Common Names	Heliogen green, monastral green, monestial green, thalo green.
Composition and Origin	$C_{32}H_{16}CuN_8Cl_{15}$ = PG 7, $C_{32}Br_6Cl_{10}$ CuN_8 = PG 36. A synthetic organic pigment, phthalocyanine. Developed, with phthalocyanine blue, since 1927.
Tinting Strength	Very high.
Shade	Very bright, cold green-blue. Available as cold blue-green (PG 7) or yellow shade (PG 36).
Opacity	Very transparent but covers well.
Suitability to Media	Stable to all media. Fine particle size means that dispersion can be difficult without prior wetting. Sometimes sold in a water-paste to ease dispersion.
Drying Rate (in oil)	Medium to slow.
Defects	Difficult to wet: prepare a paste with white spirit before grinding with oil.
Availability/Cost	High tinting strength guarantees strong colour: widely used in many paint systems but often combined with filler material to reduce tinting strength.
Comments	Sometimes appears in cheaper ranges to imitate costly viridian.
Special Note	Requires wetting agent.
Health & Safety Information	Contains copper.

NITROSO GREEN PG 8

Colour Index Number	10006
ASTM/BWS Rating	ASTM III (as Artists' Acrylic)
Common Names	Naphthol green, hooker's green, but may also be used to make imitation sap green.
Composition and Origin	$C_{30}H_{18}FeN_3O_6$.Na. Synthetic organic complex (1-nitroso-2-naphthol), in reaction with ferrous sulphate and sodium hydroxide.
Tinting Strength	Good.
Shade	Dark green.
Opacity	Transparent.
Suitability to Media	Water-based binders (not lime-fresco).
Drying Rate (in oil)	Medium.
Defects	Not stable in acid-containing mixtures. Not wholly permanent, especially when expressed as a wash in watercolour or acrylic, or when strongly mixed down with white.
Availability/Cost	Available in some paint ranges, but more often superseded by more permanent mixed colours.
Comments	May be found in some lower quality watercolours and designer's gouache.
Special Note	Requires wetting agent.
Health & Safety Information	–

QUINDO GREEN GOLD PG 10

Colour Index Number	12775
ASTM/BWS Rating	ASTM I
Common Names	Green gold lake, golden green lake, irgazine yellow (green).
Composition and Origin	$C_{30}H_{18}Cl_2N_6NiO_4$. A synthetic organic pigment. Nickel azo. Developed late 1940s, recently introduced to artists' ranges.
Tinting Strength	Good.
Shade	Warm, dark green in mass tone. When thinned to glaze, takes on a golden yellowish cast.
Opacity	Good transparency as a glaze.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Medium-Slow.
Defects	–
Availability/Cost	Introduced to updated oil colour ranges, also available as dry pigment.
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	Contains nickel.

CHROME OXIDE GREEN PG 17

Colour Index Number	77288
ASTM/BWS Rating	ASTM I
Common Names	Chromium oxide opaque.
Composition and Origin	Cr_2O_3. An artificial mineral pigment, derived from potassium dichromate, sulphur and charcoal, or by heating viridian (hydrated ferric oxide). Introduced in 1809, widely available by the middle of the 19th century.
Tinting Strength	Good.
Shade	Dull, cool olive-green.
Opacity	Good.
Suitability to Media	Stable to all media.
Drying Rate (in oil)	Fast-Medium.
Defects	–
Availability/Cost	Inexpensive, widely used.
Comments	Chrome oxide green is often overlooked by artists because of its dull shade. It has very high tinting strength and excellent covering power.
Special Note	–
Health & Safety Information	Contains chromium.

VIRIDIAN PG 18

Colour Index Number	77289
ASTM/BWS Rating	ASTM I
Common Names	Hydrated chromium hydroxide, guignet's green, transparent oxide of chromium.
Composition and Origin	Cr_2O_3. $2H_2O$. An artificial mineral pigment. Derived from bichromate and boric acid, calcined then washed. Discovered by Guignet in 1859, available commercially since the early 1900s.
Tinting Strength	Good.
Shade	Bright, deep green with bluish tinge.
Opacity	Very transparent, typical glazing colour.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Slow.
Defects	Dries with wrinkling when applied in any thickness.
Availability/Cost	Expensive, widely used.
Comments	Although phthalocyanine green is less subtle in shade, it may provide a cheaper alternative. Viridian green possesses a subtlety that is hard to match, especially in tints with zinc or lead white.
Special Note	"Victoria green" is an obsolete composition pigment, based on a mix of viridian, zinc yellow and zinc or lithopone whites. "Academy blue" denotes a mixture of viridian with ultramarine, prepared as an oil colour (Winsor & Newton catalogue of 1925).
Health & Safety Information	Contains chromium.

VERDIGRIS SYNTHETIC PG 20

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Copper acetate, copper resinate (when mixed with a balsam).
Composition and Origin	$Cu(CH_3COO)^2.2H_2O$. An artificial mineral pigment. Copper (II) acetate, 1- hydrate. Verdigris dates from antiquity. Originally prepared from copper plates or shavings, exposed to vinegar. The modern product is treated with acetic acid. In the original process, grape skins are left to decompose, lying on copper sheet, in the presence of mild warmth. After 4-5 weeks, a greenish-blue deposit develops, which is then pulverised to form a fine powder, taking on a green hue in the process. Verdigris tends to turn brown in oil, especially when admixed with pigments containing sulphur. Traditional recipes call for the combination of verdigris, locked within a resin-oil, or balsam (Venice turpentine) paint medium, to prevent the pigment contacting with the atmosphere and with other pigments. Verdigris takes the form of a crystalline powder and has a pronounced, gritty structure, which is difficult to mask in paint mixtures. Best used locked into an oil-resin paint medium.
Tinting Strength	When applied as a glaze on its own, verdigris gives a strong, dark green-blue glaze.
Shade	Dark green-blue.
Opacity	Transparent (although the particle structure tends to show).
Suitability to Media	Difficult to prepare in aqueous binders, especially acrylic. Best suited to preparation in animal glue size or casein binder, or prepared as copper resinate for use in oil paint technique.

Drying Rate (in oil)	Fast.
Defects	Verdigris is highly acidic, so assists the deterioration of paper fibres when applied in water-based binders.
Availability/Cost	Available as pigment, or premixed as "copper-resinate": $Cu(CH_3CO)^2.2Cu(OH)^2.nH_2O\text{-}Cr_2O_7.nH_2O$.
Comments	–
Special Note	–
Health & Safety Information	–

ULTRAMARINE GREEN PG 24

Colour Index Number	77013
ASTM/BWS Rating	Not tested.
Common Names	*Oltremare verde* (Italian).
Composition and Origin	$2Na_2Al_2Si_2O_6.NaS_2$. Calcined kaolin with soda, sulphur and carbon, in a process similar to that of ultramarine blue, except that a lower temperature is required. Available since 1827.
Tinting Strength	Weak.
Shade	Cold, green with slight bluish undershade.
Opacity	Transparent.
Suitability to Media	Stable in all media, except lime-fresco (similar to ultramarine blue).
Drying Rate (in oil)	Similar to ultramarine blue.
Defects	Poor tinting strength, dull appearance. Not stable in mixtures with lead-based pigments.
Availability/Cost	Not widely available, sometimes found as dry pigment, especially in Italy.
Comments	–
Special Note	–
Health & Safety Information	–

COBALT GREEN (DARK) PG 50

Colour Index Number	77377
ASTM/BWS Rating	ASTM I
Common Names	Cobalt bottle green.
Composition and Origin	Co_2TiO_4. An artificial mineral pigment, formed from calcined oxides of titanium and cobalt.
Tinting Strength	Medium.
Shade	Deep, cool green.
Opacity	Semi-opaque, tending towards opaque.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Expensive.
Comments	–
Special Note	–
Health & Safety Information	Contains cobalt.

COBALT GREEN PG 26

Colour Index Number	77343
ASTM/BWS Rating	Not tested.
Common Names	Cobalt green-blue oxide, cobalt blue-green oxide.
Composition and Origin	Cr_2O_3. CoO. Al_2O_3. An artificial mineral pigment, prepared by calcination or precipitation of cobalt carbonate with hydrated chromium oxide. Developed during the late 19th century.
Tinting Strength	Medium, stronger than cobalt green light.
Shade	Two distinct shades are available: grass green, or blue-green.
Opacity	Semi-opaque, tending towards opaque.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Expensive and not always found in artists' colour ranges.
Comments	–
Special Note	–
Health & Safety Information	Contains cobalt.

COBALT GREEN LIGHT PG 19

Colour Index Number	77335
ASTM/BWS Rating	ASTM I
Common Names	Rinman's green, cobalt blue-green light.
Composition and Origin	CoO.ZnO. An artificial mineral pigment, oxides of cobalt and zinc. Cobalt green was first developed in Sweden by Rinman in 1780, but not introduced to the market until the 1830s. Modern varieties can be based on a complex of cobalt, zinc and ammonium.
Tinting Strength	Weak.
Shade	Pale blue-green with a delicate presence in mixtures with other pigments.
Opacity	Semi-opaque.
Suitability to Media	Stable to all media but modern varieties (based on a complex of cobalt, zinc and ammonium) may not be stable in lime-fresco techniques.
Drying Rate (in oil)	Fast.
Defects	Weak tinting strength in admixtures.
Availability/Cost	Expensive, the peculiar hue of cobalt green-blue light is difficult to match through mixing.
Comments	Shows granulation when expressed as a wash in watercolour techniques.
Special Note	The exact shade of PG 19 can vary from manufacturer to manufacture.
Health & Safety Information	Contains cobalt.

MALACHITE

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Mineral green, mountain green.
Composition and Origin	Mineral pigment, natural copper carbonate, $CuCO_3.Cu(OH)^2$. Often found in association with blue azurite, to which it is closely related. Malachite is prepared by crushing, sieving and levigating the resultant powder. The particles are sorted into different grind sizes, according to the depth of colour and exact particle size required. In fresco, larger particles can be utilised, to preserve the strongest colour value.
Tinting Strength	Weak.
Shade	Pale green with bluish cast. Chrysocolla (copper silicate, $CuSiO_3.nH_2O$) is a blue-green form of malachite, a dull turquoise.
Opacity	Tends towards opaque.
Suitability to Media	Not suitable in oil binders, where it takes on a greenish appearance. Best used fresh in fresco, as malachite will change colour when left to steep in water. In water-based binders such as glair (egg white), casein and gum arabic, the true pale green quality of malachite can be preserved.
Drying Rate (in oil)	–
Defects	Poor tinting strength in mixtures.
Availability/Cost	Available in a variety of grind sizes: the finer grades are progressively weaker in colour, according to the smallness of the particle size.

Comments	In historical paintings, malachite is sometimes admixed with organic greens from plant stuff, such as the yellow colour derived from weld. Similarly, green earth was sometimes enhanced in colour by admixture with malachite.
Special Note	–
Health & Safety Information	Contains copper.

MALACHITE (SYNTHETIC)

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Copper carbonate, mountain green, green bice.
Composition and Origin	$CuCO_3Cu(OH)_2$. Copper carbonate. An artificial mineral pigment. Chemically similar to natural malachite (basic copper carbonate). A bright, soft powder. This is a modern, industrially made equivalent to the historic pigment green verditer, in the form of a finely divided powder (less coarse than historic green verditer).
Tinting Strength	Medium.
Shade	Cool green-blue, more intense than natural malachite.
Opacity	Good.
Suitability to Media	–
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Available as pigment. Malachite "hues" appear in paint ranges, which are mixtures of other pigments.
Comments	–
Special Note	–
Health & Safety Information	–

CADMIUM GREEN

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Cadmium green light, cadmium green dark.
Composition and Origin	An artificial mineral pigment: mixture of a) synthetic ultramarine and cadmium yellow; b) viridian and cadmium yellow, or similar mixtures of reliable, permanent pigments. Introduced as a standard artists' colour in Germany, during the 1920s.
Tinting Strength	High.
Shade	Bright lime green/grass green (light and dark shades).
Opacity	The inclusion of ultramarine or viridian gives a semi-opaque quality.
Suitability to Media	–
Drying Rate (in oil)	Slow.
Defects	–
Availability/Cost	–
Comments	Various mixtures approximate cadmium green light and dark, in manufactured paint ranges. The dry pigment is also commonly available, usually in two shades – light and dark.
Special Note	–
Health & Safety Information	–

GREEN VERDITER

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Mountain green, cendres green, green bice.
Composition and Origin	$CuCo_3.(OH)^2$. Basic copper carbonate pigment, formed by the precipitation of copper sulphur, from a combination of potassium and lime (or in England, chalk), with copper sulphate and ammonium chlorate. Developed since the 17th century and widely used in decorative paints, although today considered an obsolete colour. Larger particle size when compared to synthetic malachite.
Tinting Strength	Weak.
Shade	Pale green-blue, especially in water-based binders.
Opacity	Semi-opaque, powder usually has a crystalline structure.
Suitability to Media	Unstable in all media, especially oil, where it turns dark green.
Drying Rate (in oil)	–
Defects	Discolours in oil (darkens).
Availability/Cost	–
Comments	–
Special Note	–
Health & Safety Information	–

VOLCHONSKOITE GREEN

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Russian green, wolchonskoite green.
Composition and Origin	$Ca_{0,3}(Cr^{+3},Mg,Fe^{+3})_2(Si,Al)_4O_{10}(OH)_24H_2O$. Natural clay-containing mineral pigment, the colour formed by natural chromium oxide. Sources located only in the former Soviet Union (Perm Basin, Okhansk, but also found in the Ural mountains). The pigment is named after the 19th century Russian Imperial Court minister, Prince Volkonskoi.
Tinting Strength	Good, far superior to green earth.
Shade	Dark green pistachio colour, but available in a variety of shades, from darkish olive green-brown to bright earth green, or even emerald.
Opacity	Good transparency.
Suitability to Media	Stable in all media, especially oil, where its low oil absorption rate (15-25g) makes it far superior to green earth.
Drying Rate (in oil)	–
Defects	Unavailable to the general market, but found in Russian paint ranges.
Availability/Cost	Available in Russian paint ranges and as dry pigment.
Comments	A valuable and unique pigment, especially beautiful when mixed with small amounts of zinc white, to form cool olive green shades.
Special Note	–
Health & Safety Information	–

SCHWEINFURT GREEN

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Emerald green (manufactured form), also mittis green, imperial green, vienna green, scheele's green, paris green, veronese green, etc.
Composition and Origin	$CaCu(AsO_4)(OH)$. Conichalcite is a natural mineral copper-arsenic-carbonate compound. A natural mineral pigment containing arsenic, and therefore toxic. The name – Schweinfurt – relates to the town where the brighter, artificial form (emerald green) was first manufactured, in 1814. Emerald green (PG 21/C.I. 77410) is basically copper aceto-arsenate, derived from verdigris which is combined with a boiling water-solution of white arsenic. An earlier form, dating from 1778 and known as scheele's green (PG 22/C.I. 77412), is copper arsenite, bearing an excess of copper oxide.
Tinting Strength	–
Shade	The natural pigment is a dark, crystalline green, similar to green earth. The prepared pigment is a bright acid-green colour, similar to emerald.
Opacity	Emerald green is more opaque than scheele's green.
Suitability to Media	Unstable, especially in water-based binders.
Drying Rate (in oil)	–
Defects	In watercolour, copper-arsenate pigments quickly darken, while in oil, admixtures with any sulphide containing pigments turn brown or black.
Availability/Cost	Highly toxic, no longer supplied in paint form.
Comments	–
Special Note	Considered obsolete but may be required in relation to painting conservation.
Health & Safety Information	Toxic.

BLACK AND BROWN PIGMENTS

LAMP BLACK PBk 6

Colour Index Number	77266
ASTM/BWS Rating	ASTM I
Common Names	Furnace black, gas black, blue black, carbon black.
Composition and Origin	C (amorphous carbon). Use of lamp black dates back to antiquity. Originally, lamp black was made from the soot from oil lamps/fireplaces. Modern lamp black is produced from partially combusted mineral and/or vegetable oil. Pure carbon. Oily residue is removed during the manufacturing process. The dry pigment is very light and forms a soft powder.
Tinting Strength	Good.
Shade	Intense blue-black, with a cold tinge. As an oil colour, gives a deep, velvety black.
Opacity	Very transparent.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Very slow.
Defects	Very high oil absorption: use in thin layers only (thick layers tend to wrinkle and take forever to dry out). Difficult to combine with oil: wet the pigment first with white (mineral) spirit to form a stiff paste.
Availability/Cost	Common to most oil paint ranges.
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

IVORY BLACK
(Black from charred bones) PBk 9

Colour Index Number	77267
ASTM/BWS Rating	ASTM I
Common Names	Bone black.
Composition and Origin	Natural pigment from animal origin (C,Ca_3 $(PO_4)^2$). Originally from calcined ivory but now commonly from charred bones. Genuine ivory black contains more carbon than the modern product and has a higher tinting strength.
Tinting Strength	Good.
Shade	Slight brown or grey tinge.
Opacity	Not transparent but thins to a glaze.
Suitability to Media	–
Drying Rate (in oil)	Very slow drier, forming relatively soft, brittle films. To be avoided in underpaintings, unless admixed with fast-drying pigments such as lead white or raw umber and applied as a thin coating.
Defects	Slow drying can cause matting/sinking of paint film. Grind thoroughly to combine oil and pigment particles.
Availability/Cost	Inexpensive, replaces genuine ivory black.
Comments	Additions of painting medium can help counter sinking/matting of paint film.
Special Note	"Bone brown" is a variation of ivory black, which gives a gentle, transparent brown colour, ideal for use in watercolour mixed colours (e.g. "olive lake", with stil de grain and ultramarine).
Health & Safety Information	–

MARS BLACK PBk 11

Colour Index Number	77499
ASTM/BWS Rating	ASTM I
Common Names	Iron oxide black, mineral black.
Composition and Origin	$FeO.Fe_2O_3$. An artificial mineral pigment – see synthetic iron oxides. Ferro-ferric oxide. Production of mars black dates back to the 1920s.
Tinting Strength	Good.
Shade	Deep black (not as saturated as ivory black), also brown and blue-black shades.
Opacity	Good.
Suitability to Media	Stable in all media.
Drying Rate (in oil)	Medium.
Defects	Opacity may render mars black slightly less subtle than transparent blacks, when intermixing with other transparent colours to gain neutral tints.
Availability/Cost	Cheap, easy to use from dry pigment. Found in most oil colour ranges.
Comments	–
Special Note	–
Health & Safety Information	–

MANGANESE BLACK PBk 14

Colour Index Number	77728
ASTM/BWS Rating	Not tested.
Common Names	Manganese grey, manganese brown, according to shade.
Composition and Origin	MnO_2. Manganese dioxide natural mineral pigment. Has been used sporadically by artists since the early 1900s.
Tinting Strength	Strong.
Shade	Neutral black-grey.
Opacity	Semi-opaque.
Suitability to Media	–
Drying Rate (in oil)	Very fast.
Defects	–
Availability/Cost	Not widely used in tube oil colours, although the pigment is relatively inexpensive.
Comments	A useful, fast-drying black.
Special Note	–
Health & Safety Information	–

SPINEL BLACK PBk 26

Colour Index Number	77494
ASTM/BWS Rating	Not tested.
Common Names	Manganese ferrite spinel black, cobalt black.
Composition and Origin	An artificial mineral pigment. Spinel: procedure similar to manufacture of cobalt pigments. Recently introduced.
Tinting Strength	Very good – multiple glaze layers give the deepest blacks.
Shade	Deep, slightly blue-black.
Opacity	Good transparency as glaze.
Suitability to Media	–
Drying Rate (in oil)	Fast.
Defects	–
Availability/Cost	Expensive, available as pigment and in some updated oil colour ranges.
Comments	–
Special Note	–
Health & Safety Information	–

SEPIA Natural Brown 9

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	–
Composition and Origin	$CaCO_3$. The ink sac of the cuttlefish provides a dark brown-black pigment. In nature, when the fish is attacked, it releases a jet of ink into the water, to confuse prey. This ink sac can be dried, washed free of salt water and carefully dried, then pulverised to form a powder and then boiled with lye (potassium hydroxide). The resultant coloured liquid is precipitated with hydrochloric acid, washed and then left to dry out thoroughly. Today, the term, "sepia" is often used to describe browns, brown-blacks and red-browns in ranges of inks and paints. As a consequence, the exact colour of sepia is known to few people. The true colour of sepia is a very dark brown, virtually black, that possesses a slight transparency when diluted, or when added to glazing media. From the late 1700s, sepia was widely used as an ink and wash colour for works on paper. Old recipes mention two distinct forms of sepia: a) sepia used alone, as a simple black-brown colour; b) sepia admixed with red madder lake to give a warmer tone. During the 19th century it was sometimes used as a pigment for oil painting, although it is not lightfast enough for this purpose.
Tinting Strength	High.
Shade	Deep brown black, turning slightly warmer (redder) in hue when exposed to light. Modern pigment mixtures called sepia often have this warm red-brown appearance. The dark colour is preserved somewhat if finished artworks are stored in closed portfolios and only shown in subdued lighting. "roman sepia" is a warm red-brown formed when sepia is admixed with a red lake such as carmine or madder.
Opacity	Semi-transparent.
Suitability to Media	Best suited to gum arabic, or shellac-borax binders, applied to paper.
Drying Rate (in oil)	Not stable in oil.

Defects	Fugitive to light.
Availability/Cost	Best quality sepia is presented as dry pigment, washed and divided into three distinct grind sizes.
Comments	–
Special Note	Requires wetting agent. In the 19th and early 20th centuries, artists' watercolours were commonly prepared with carefully processed natural sepia. However, the pigment is unusable in oil, where mixtures of natural earths (e.g. cologne earth with bone brown) can be used.
Health & Safety Information	–

FRUIT STONE BLACK

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Peach black, nut black, cork black, etc.
Composition and Origin	C (carbon + various impurities). A simple carbon black, produced by calcining fruit stones (walnuts, peach, cherry, pear, almond, chestnut, or even cork). The colour produced varies from deep brown to velvet black, according to the type of stone and length of exposure to heat. The author has prepared pigment from peach stones, forming a warm deep brown. The stones require pulverisation to form a fine powder.
Tinting Strength	Poor.
Shade	Brown to black.
Opacity	Tends towards transparency.
Suitability to Media	Formerly found in oil and watercolour paint systems.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Formerly available in French and Russian paint ranges or as dry pigment.
Comments	Peach black is often confused with vine black, both being basic charcoals.
Special Note	The Leningrad Paint Plant (now St. Petersburg Paint Plant) of the former Soviet Union include genuine peach black (catalogue of 1991) in their list of oil colours, the colour described as being "deeply bluish black, obtained [from] peach stones [by] calcinations".
Health & Safety Information	–

ATTRAMENTUM

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Iron scale black.
Composition and Origin	Attramentum is made by reacting the tannic acid of oak bark with iron salts. This produces a deep black with a violet tinge (as a glaze).
Tinting Strength	Strong, in oil.
Shade	Deep black with violet undershade.
Opacity	Semi-opaque.
Suitability to Media	In oil, forms a deep, velvet black, which is stable. Lightfast.
Drying Rate (in oil)	–
Defects	In water-based media, attramentum can have a corrosive effect on paper supports.
Availability/Cost	Available as dry pigment.
Comments	–
Special Note	–
Health & Safety Information	–

BISTRE

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	–
Composition and Origin	CnH2n+2. The soot from burning beech wood or birch wood has a tar-like quality. It can be washed, sifted and pulverised to form a slightly bituminous pigment known as bistre. Bistre is known to fade or become pale in strong light, through oxidisation. Many ink and wash drawings from the 1600s were made with inks based on bistre mulled into gum arabic, or shellac soap (shellac and borax). Bistre is a deep-blackish brown with some transparency. When the pigment is steeped in turpentine it forms a sticky mass, similar to bitumen in consistency. It can be used to tint oil-resin mediums with a clear-transparent brown effect, but dries poorly.
Tinting Strength	Poor.
Shade	Cold brown-black in water-based media, shows some warmth when ground in oil.
Opacity	Good transparency.
Suitability to Media	Best suited to liquid ink, using a shellac-borax based binder (water-thinnable but insoluble when dry).
Drying Rate (in oil)	Poor drier in oil.
Defects	Fugitive to light.
Availability/Cost	Available as a dry pigment and as ready-made "bistre ink".
Comments	–
Special Note	Requires wetting agent.
Health & Safety Information	–

PRUSSIAN BROWN

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Berlin brown.
Composition and Origin	$Fe_4[Fe(CN)_6]^3$. Prussian brown (available from 1704) is a by-product of prussian blue. A stable, transparent brown can be processed from prussian blue (ferric ferrocyanide). The blue pigment is calcined while exposed to air, turning to cyanogen (manufacturing of prussian brown is hazardous, which to some extent explains the limited use of this pigment) and ferric oxide.
Tinting Strength	Medium.
Shade	Dull, neutral brown, enhanced in oil-resin glazes.
Opacity	Transparent.
Suitability to Media	Stable in oil and watercolour.
Drying Rate (in oil)	–
Defects	–
Availability/Cost	Rarely available, sometimes as dry pigment.
Comments	–
Special Note	–
Health & Safety Information	–

BITUMEN

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	Asphaltuum.
Composition and Origin	C_nH_{2n+2}. Asphaltuum, formed after the evaporation of petroleum. Bitumen or asphaltuum, occurs naturally in low-lying or sub zero level locations such as the Dead Sea in Israel/Syria, Peru, Albania, and Gilsonite in the United States. In nature it is found as a black, tarry substance which is collected, for example from the surface of the Dead Sea, then dried and pulverised. In former times it was also found in Sicily and is sometimes even referred to as Sicilian Oil. It can also be artificially prepared from brown coal and coal tar. It tends to dissolve in drying vegetable oils such as linseed oil but may also be dissolved in (warm*) turpentine to form a simple, tacky mass that can be used as a transparent brown glaze. As bitumen is carefully dissolved, then diluted with turpentine, it reveals a clear, warm brown colour, which can be brushed out to form a thin glaze. By contrast, undiluted it has a thick, viscous tarry presence and is unpleasant to work with in both smell and consistency. Bitumen, despite its pleasing warm-brown colour is a technical nightmare: it never completely dries as a paint film and remains susceptible to temperature changes. For example, in the summer, paint films may re-open and become tacky. As a consequence, in oil paint technique bitumen has no practical importance, unless used to tint an oil-resin glaze, where its pronounced detrimental properties are slightly reduced. * Warm turpentine in a warm water bath – not direct heat source. Turpentine and all solvents are highly flammable.
Tinting Strength	Poor – does not mix well with other pigments.
Shade	Warm, rich brown-black.

Opacity	Transparent.
Suitability to Media	Not stable in any media.
Drying Rate (in oil)	Does not dry.
Defects	Poor drying.
Availability/Cost	Available as a paste, or in dry powder form and still in some oil paint ranges.
Comments	Best avoided – but remains of importance to painting conservation and to those interested in painting techniques of the past.
Special Note	–
Health & Safety Information	–

VINE BLACK

Colour Index Number	–
ASTM/BWS Rating	Not tested.
Common Names	French vine black, blue black.
Composition and Origin	C (pure carbon). A natural vegetable pigment: made from charred vines. Pure carbon. Dates from antiquity.
Tinting Strength	Medium.
Shade	Cold grey-black.
Opacity	Good transparency.
Suitability to Media	–
Drying Rate (in oil)	Very slow.
Defects	–
Availability/Cost	Common to many paint ranges: a variety of vine blacks are available as dry pigment.
Comments	Pigment as powder has a mild grainy presence, which can be smoothed to some degree by extra grinding in a pestle and mortar.
Special Note	Requires wetting agent.
Health & Safety Information	–

Miscellaneous Pigments

Pigments that may have advantageous or interesting properties for special techniques

This section includes a number of pigments that may now be considered obsolete (i.e. no longer available).

Alizarin Green

Early coal tar dye colour. Not permanent. Alizarin green progressively darkens on exposure to light, moving towards black. Obsolete.

Alizarin Brown, $C_6H_4(CO)^2C_6H_2(OH)^2$

Also known as brown madder. Has similar properties as alizarin crimson, but is no longer in general manufacture. Some shades of natural madder may also share this name. Obsolete.

Aloe

A brown, with a warm tinge can be prepared from the juice of aloes, native to South Africa (Port Elizabeth) and India. The dried aloes are steeped in alum-rich water (similar to the making of sap green) and the resultant sticky colour can be used as a simple watercolour paint on to paper. Fugitive to light.

Antimony Orange, Antimony Gold, Antimony Vermilion. Goldschwefel in German. Sb_2O_3

Unstable in mixtures with lead-based pigments, antimony orange is a trisulphide of antimony. It is available in a number of shades, from dark yellow-orange through to orange-red. Developed in the 1840s in Scotland, by Murdock & Co and C. Himly in Germany.

The pigment is dull in appearance in powdered form but becomes rather more glowing and brighter when mixed with a binding agent. Inclusion of free-sulphur in the manufacturing process leaves antimony orange rather unstable, especially when in contact with lead-based pigments.

Antimony Oxide White, Sb_2O_3

Antimony oxide is sometimes found in industrial paints. It darkens when in contact with hydrogen sulphide. As a consequence, it is prepared by co-mixing with zinc oxide (which is able to absorb hydrogen sulphide). Alone, antimony oxide white is very opaque, similar to titanium white. Developed in the 1920s but of no practical importance as an artist's material. Obsolete.

Bismuth White, PW 17, $BiOnO_3.H_2O$

Less toxic than lead white. Bismuth white (bismuth nitrate) was used as an alternative to lead white in the early 19th century, prior to the introduction of zinc white. It is affected by sulphurous compounds and has a tendency to turn black on exposure, at a more accelerated rate than is the case with lead white.

Bone Ash (tricalcium phosphate)

The white-grey ashes from burnt bones can be used with animal skin glue binder, or casein binder to give a ghostly grey-white colour. Bone ash is more commonly used as an addition in metalpoint/silverpoint grounds and as a thickening agent in lime-fresco.

Brazilwood, $C_{15}H_{12}O_5$

A red-brown lake can be prepared from yellowish brazilwood chippings, by boiling in water, then straining the resultant coloured dye and allowing it to form a dry residue, which is then pulverised to a powder.

This red-brown lake was commonly found on painting from the middle ages, when the source for the colour came from Sri Lanka.

The same wood was also discovered in South America and lends its name to the modern country of Brazil. Fugitive to light.

Coloured Marble Dusts

Coloured marble dust in the form of chips, sized between 0.7-4.0mm can be used to create textured effects in a variety of binders, especially when incorporated into fresco techniques. It can also be safely used with various acrylic binders. The different chip size provides a variation of hue, with the palest shades resulting from chips of the smallest size. Coloured marble dusts are available in colours ranging from white, cream/ivory, pale ochre-like yellow, brown-pink, green, red-pink and black.

These coloured marble dusts can also be used with strong protein glue binders, especially casein-ammonium carbonate (see Lime-Fresco chapter, for binder recipe). Other coloured rocks such as quartz chips (orange-red), granite (grey) and basalt (black/grey) can be used in a similar fashion and offer specialised textured effects, especially when used in fresco ground layers.

Fluorescent Colours

These "pigments" may be produced by combining fluorescent dyes with fast-setting resin. The hard resin is then pulverised to a powder form to enable paint to be made. These fluorescent or "dayglo" colours have been formulated to encourage reflectance of UV light and are supplied in the following shades: white, blue, green, lemon yellow, golden yellow, orange, brick red (pink), flame red, magenta red.

The fluorescent colours show best light reflectance when painted on to white primed grounds and better still when lit only by UV lights. They are not permanent and will lose their brilliance in a matter of months when exposed to daylight. Some colours appear more fluorescent than others. For example, the pink, red and lemon yellow shades do seem to glow. By contrast, the blue is slightly dull when painted out and compared to manganese blue pigment.

Special UV light absorbing varnishes are available which can be applied over the fluorescent colours, they do not stop the fading of fluorescent pigments but will slow down the rate of change. These varnishes are normally based on acrylic resin formulations.

In practice, the fluorescent colours work best into acrylic binders. For best light reflectance, they should be mixed with the acrylic resin binder and expressed on to the painting surface immediately (i.e. not left to stand). To increase light reflectance, co-mix with hollow glass beads – this has the effect of increasing luminosity. If any filler material is included in the basic paint mixture, the resultant colour will not appear particularly fluorescent. This is especially so with cheaper acrylic brands that include fluorescent colours. In oil, the fluorescent colours appear rather dull.

Glass Pigments

Coloured ground glass is manufactured by fusing lead crystal glass and other metals (e.g. cadmium, copper, nickel, cobalt, selenium) to create a spectrum of colours. These coloured ground glass pigments are widely used in the glass-blowing industry, especially in Venice and the Czech Republic. The technology surrounding the development of coloured glass pigments has a long history. In Venice, for example, as early as 1292, the city had gathered all glassware production on the island of Murano, and even today, Murano remains an important centre for glassmaking.

Although coloured glass is normally associated with these centres of glass-blowing and glassware production, when a smaller particle size is created, coloured glass can be used in various paint binders with some success. The base material is first pulverised, then graded according to micron (grind) size. The particle size of such glass pigments may thus range from 63m to 125m, the size of the particle determining the exact shade of colour – a very fine particle size gives a much paler hue. This represents the same phenomenon exhibited by smalt, but also relates to the crystalline mineral pigments (e.g. malachite, azurite), where in order to achieve a strong colour, the pigment is required to be used in a grittier particle size. This somewhat limits the use of coloured glass pigments in terms of painting, unless one is happy for the paint film to include a textured surface. Pale or waterclear binders show the colour of the glass to best effect. As a consequence, acrylic binders may be the most suitable, in particular, acrylic gel mediums, which possess body and clarity. In such systems, the glass is encapsulated in the acrylic gel film, so guaranteeing good adhesion to the support. However, encapsulation within an acrylic binding somehow lessens the colour effect, because light is effectively swallowed into the acrylic resin paint film. By contrast, when the glass pigments are carefully used in oil binders, they can provide both colour saturation and transmission of light. The best policy with oil is to use a pale sun-bleached linseed oil, combined with a slightly warm addition (perhaps 20-30%) of Venice turpentine. The Venice turpentine deepens the gloss of the pigment but also helps light to pass through the paint film. The pale sun-bleached linseed oil does not show yellowing and creates enough binding with the Venice turpentine to hold the glass pigment to the support. The Venice turpentine needs to be slightly warm (place container in a warm water bath before applying) in order for this oleo-balsam to flow sufficiently to be able to brush out. Careful use of these glass pigments in this oleo-balsam formula will give rich, glossy, luminous paint coatings, where the granular particle size is partially hidden in the thickness of the binding.

Although the coloured glass pigments can be construed as toxic when burnt, giving off noxious fumes, in their powdered state they are relatively inert. Even so, because they contain lead and other heavy metals it is advisable not to breathe in dust when working with the loose powder. Glass pigments are stable to light and protected from damage by air pollutants. They can be used with any binder, although in fresco techniques they may cause surface problems such as blooming. In short, glass pigments represent one of the best possible forms of pigment, in that all colours react identically to any binder and particle sizes are sorted into different grind sizes, so the artist can adopt whichever is most suitable. If one drawback with these pigments is their weak colour when used at the small grind size, then another problem is the range of colours available. As already stated, the colours are only strong in large particle format, so one tends towards making paintings that show pale tints. Also, the colours cannot be successfully intermixed: they need to be laid over each other to gain any kind of colour transformation, although not all glass pigments are absolutely transparent. They are best used alone, with colours being placed size by side, using different grind sizes to apportion control of lights and darks.

Inert Fillers

Low tinting strength whites such as blanc fix and aluminium hydrate can be used in painting practice, with care, as colours in their own right (see White Pigments section). A number of other white or off-white inert pigments/fillers can also be considered.

Into animal skin glue binders, white chalk can be used as a pure white pigment: whiting (calcium carbonate) or gypsum (calcium sulphate) are examples. Kaolin and china clay (PW 19) are forms of aluminium silicate and are often used as extender/filler material, especially in school paints and some industrial paints. Kaolin is the brightest white form of china clay. Both forms are used for their cohesive properties in the manufacture of soft pastels, graphite pencils and coloured pencils. However, due to their fast-setting properties when admixed with cold water, they have been used successfully to make temporary wall drawings.

Logwood, $C_{16}H_{12}O_6$

A plant colour, giving a red colour when boiled in water, but can be reacted with various metal mordants (tin, alum, etc) to give different dye colours, especially black, or brown-black and blue-black. It can also be developed as a "lake" in a process similar to that for natural madder. Fugitive to light.

Luminous Pigments

Luminous or phosphorescent pigments are based on heat-fusions of heavy metal sulphides such as cadmium or zinc, in combination with small trace elements of other minerals. Such pigments glow or luminesce in the dark. They store light when exposed to strong light sources, then when placed in the dark, the pigment emits this light, usually showing a white-green effect. Gradually the phosphorescent effect wears down, and even after re-exposing to strong light, the glowing effect becomes progressively weaker. As a consequence, such pigments cannot be considered for permanent works of art but may be successful in the context of installation work, or for decorative purposes.

Some phosphorescent pigments only emit this glowing effect when shown in black light (i.e. a room devoid of natural light and lit only by UV light).

Magenta, $C_{20}H_{20}N_3Cl$

Also known as fuschin, magenta is a red-purple dyestuff, developed from 1856 and named after an Italian town. Along with mauve, it was used during the 19th century, particularly in watercolour and gouache paints. May still be used in some cheaper water-based paints, although this colour can be readily matched by a number of permanent quinacridone pigments.

Mauve, $C_{27}H_{25}N_4(SO_4)$

The first synthetically made dyestuff, discovered accidentally by William Perkin in 1856. Mauve is an aniline dye, prepared from a distillation of coal tar. It was used in watercolour paints in the 19th century, but its fugitive nature and tendency to bleed render it unsuitable as an artists' material. Obsolete.

Metal Powders

Some powdered metals can be considered permanent for painting purposes. For example, stainless steel powder can be used in linseed oil to effect a dense, metal grey. Similarly, carborundum powder, a grit normally used for re-grinding the texture on the base of glass mullers, is stable in oil and makes a heavy metal black-grey. Metal powders have no intrinsic tinting strength: when admixed with opaque pigments they disappear, perhaps leaving only their texture behind. Some metal powders are prone to change upon exposure to atmosphere: for example, aluminium does not tarnish as some metals do, rather it corrodes, developing an unhealthy pale, dull grey appearance. Similarly, copper powder gives a bright, bronze finish, but this effect changes on exposure to acids, where the copper turns bright green. This patination may be aesthetically pleasing, but it indicates instability and of course more changes can occur after the initial tarnishing.

When such metal powders are bound in acrylic, they may have a better chance of remaining intact. However, such mixtures should be made and used at once. Acrylic-metal combinations containing water may discolour/tarnish rapidly if left to stand. Some proprietary brands of acrylic colour include metal hues, which may be based on metals such as aluminium, copper and stainless steel. For correct use of these colour types, refer to the manufacturers' instructions. Caution is recommended in the use of metal powders: not only are some metals highly toxic, but because of the heavy nature of the material they should never be ingested through inhalation. Always wear a dust mask when working with such products in dry form.

Examples of Metal Powders

Aluminium, in powdered form, Pigment Metal 1/C.I 77000

Bronze powder, Pigment Metal 2/C.I 77400

Bronze powders can be mixed alloys of the following:

a) zinc, aluminium, copper, tin

b) iron, zinc, copper

c) zinc, copper (sometimes with other metals)

d) copper

Bronze powders are presented as coarse particles, of varying size, according to quality and end use. The four shades indicated can vary widely from brand to brand and many other intermediary shades are available. Fusion with synthetic organic pigments and/or synthetic dyestuffs, were previously available under the name of “blitzer bronze”. As indicated, metal powders – especially the bronze powders – are susceptible to tarnishing or oxidisation and as a consequence, are rarely considered for use in permanent works of art.

Gold, in powder, leaf or foil, Pigment Metal 3/C.I. 77480

Chemical formula: Au. Gold can be used in water-based binders in powdered form. The raw gold powder is carefully combined with gum arabic solution, or solutions of gum tragacanth, isinglass, or acacia (clear, pouring) honey. In such preparations it has been used in the context of illuminated manuscript painting, but also finds use in gilding techniques, when patching in broken areas of gold leaf. The high cost of gold in powdered form limits its use in painting, but it has successfully been employed in miniature painting and is effectively stable in all binding systems (but works best into clear water-based binders as indicated).

Tin, in powder or foil, Pigment Metal 5/C.I 77860.

In early panel paintings, tin foil was often used to imitate gold. The leaf was applied as per gold leaf, then varnished with a warm yellow-coloured lacquer, such as that obtained from the plantstuff saffron ($C_{20}H_{24}O_4$). Unlike silver, tin does not tarnish or discolour with age. Tin powder has a soft silverish colour and can be mixed with oil, oil-resin paint medium or alkyd resin, to make a thin paint film, which is best applied as a top coat over dried layers of paint.

Mica

Natural forms of mica are available. They have less sheen when compared to pearlescent pigments (which are usually based on a manufactured fusion between mica and other pigments such as titanium white), and tend to respond differently, according to the type of binder used. For example, muscovy glass, also known as muscovite mica, is the simplest form of potassium aluminium silicate, sold in the form of small platelets or pulverised to a fine grain powder. This form of mica will give a soft sheen when used with pale, water-based binders such as dilute animal skin glue, isinglass or very dilute acrylic resin binders. When used with oil, it forms a mushy paste which shows only the colour of the oil used. Some forms of mica such as phlogopite have a definite colour, in this case, a bronze-grey, again seen to its best advantage in pale water-based binding media.

As with pearlescent pigments, the micas show best when painted against dark grounds.

Mosaic Gold ("purporino")

PY 38/C.I. 77878. An artificially made pigment, stannic (tin) sulphide, Sn S2. Small yellow scales, similar in appearance to bronze metal powder. Mosaic gold can be used to give imitation gilding effects and is stable in most binding systems. Toxic when ingested. Obsolete.

Mummy

The Egyptian practice of embalming dead bodies of humans and sacred animals in asphaltuum (bitumen) was, for a short period the source for a dark, transparent brown, known as "mummy brown", or "caput mortuum" (literally "dead-head"). The embalmed body, including bones, was simply ground to a fine powder.

The composition is more stable than asphaltuum, because a great portion of the volatile hydrocarbons normally present in asphaltuum have evaporated over time. The pigment was used in the 19th century and has been recorded as being on sale right into the 1920s. It was a particularly useful colour in oil painting, providing excellent glazing properties. Obsolete.

Modern caput mortuum may be synthetic iron-oxide red-violet (mars violet), or may indicate a red-violet, or brown-violet shade of naturally occurring iron oxide/haematite.

Pumice

A glass, comprising elements of potassium and aluminium silicate. A type of volcanic ash, available as a gently coarse powder, or in small lumps or "stones". Pumice is found in many areas of the world, close to recent volcanic activity, especially the Lipari islands off the coast of Sicily.

The stones can be used to abrade the surface of raw linen, to remove any knots or faulting, prior to the application of sizing/priming. The powdered form of pumice is useful in certain painting grounds, especially for soft pastel, providing a toothy support. The preparation of soft pastels using pigment, china clay, etc with an addition (perhaps 10%) of pumice powder, provides a pastel stick which is easy to break against a similarly toothy support surface. Pumice can also be combined with gum arabic and pigment, to make a gouache paint with a slightly granular texture. Pumice can be incorporated into acrylic gels and mediums to give a variety of textured effects.

Silver Glitter

When thin aluminium sheets are coated in epoxy resin, then stamped to produced a variety of different sized platelets, a new material, silver glitter is formed. These silver glitter pigments do not corrode through oxidisation, as is normally the case with aluminium. Additionally, they can be used in conjunction with acrylic binders, co-mixed with synthetic organic pigments to create glowing, luminous coloured flakes within a paint film. Some experimentation is required in terms of fluidity of medium with these flakes of glitter, but with careful manipulation it is possible to lay down even paint films with a glittering nature.

Turner's Yellow, Mineral Yellow, Patent Yellow, $PbC_{12}7PbO$

Lead oxychloride. Patented by William Turner in 1781, but first developed by Carl Wilhelm Scheele in the 1770s. Formerly available in shades from yellow through to orange. Turns black on exposure. Not permanent. Obsolete.

Tyrian Purple, Imperial Purple, $C_{16}H_8Br_2N_2O_2 + SnO_2 . nH_2O$

A purple colour from a species of Mediterranean molluscs, *Murex trunculis* or *Murex brandaris,* was once used to colour the robes of Roman emperors. To gain a strong colour, millions of these small whelks are required. For example, tests made by Friedlander in 1908, required over 12,000 *Murex brandaris* to provide just over a gram of dye. Pliny mentions that this colour was produced at Tyre, hence the name. It is possible that this purple colourant was used throughout the Mediterranean and even Atlantic seacoasts up until the middle ages. Although its chief use seems to have been in textiles, it is thought to have been used in the production of illuminated manuscripts.

Drawing Materials

Drawing materials can be dry or wet: both types are used to design or outline form. The exact nature of drawing is a difficult thing to pin down. In the past, drawing was generally related to the production of paintings, and in many cases drawing would have taken place below the applied layers of paint, as a kind of guide. In more recent times however, drawing has taken on a more independent role whereby the result of drawing can be seen by the viewer as a finished artwork.

The dry types of drawing material include familiar items such as pencils and charcoal, but also more unusual, or seemingly outmoded tools, such as silverpoint. Similarly, materials commonly used for drawing that are in liquid form, can include ink, but also dilute forms of many paint types (e.g. watercolour, acrylic).

The exact identity of a drawing material may be hard to define, especially when some of the same materials are used to paint, however, it is the intention of the drawn mark which makes the crucial difference. With drawing, there is always the sense of finding form through expressed marks, whereas with paint, other considerations – particularly form through colour – are important. It is perhaps wisest to say that drawing reaches into painting, when required.

The choice of drawing materials today is wide, as are the types of support applicable to drawing. In considering each drawing "tool" in turn, suitable supports have been suggested. This is by no means a prescriptive list, there may be other ways to employ drawing materials and artists are as always encouraged to experiment.

Dry Drawing Tools

Graphite

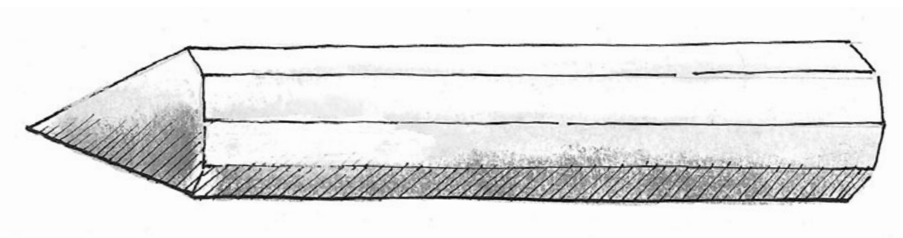
Graphite is an allotrope of carbon, occurring in a semi-crystalline, brittle form, which is found in many parts of the world. In industry it has long been used as a lubricant, due to its greasy nature. Most commercial supplies of graphite today are from Sri Lanka. However, graphite was mined in the English Lake District, from the 1660s. At Borrowdale, a graphite mine was worked for many years, supplying drawing and writing tools. The precious nature of graphite was such that it was given an armed escort on its way to London from the mine. The crudest lump form of graphite can be used as a drawing tool, although the mark given out by such pieces can be uneven and even scratchy, depending on the type of paper support used. However, lump graphite can also be supplied in a shiny, smooth form, which easily glides over the surface of paper. Check the consistency of a graphite lump before purchasing.

In general, graphite in lump form is best applied to a paper that has a very slight tooth. Perhaps the ideal support is a smooth/hot pressed 300gsm watercolour paper, which has been coated with one thin layer of rabbit glue size and fine pumice powder. When dry, this surface is slightly toothy, catching the mark of the gently applied graphite lump. This type of support will also mean that little or no fixative need be sprayed on to the drawing surface to preserve it intact. The rabbit glue size needs to be dilute and somewhere in the ratio of one part glue grains to 30 parts of water. This should be left to soak for 30 minutes, then gently warmed through by sitting the vessel containing the glue in a warm water bath for five to ten minutes. Once formed into a clear solution, a pinch of pumice powder is slowly sprinkled into the glue (about 10-20% powder to the volume of glue). When dry, the grainy particles of pumice stand up slightly in the glue layer, forming a kind of toothy grip coat. Once applied to the support, pure lump graphite can be easily smudged into the support surface to create tonal effects. It can also be erased using proprietary brands of putty rubbers or gum erasers, or by taking some soft white bread, forming it into a ball and impressing it into the drawing surface.

Graphite is also sold in the form of powder, in both a silver-grey and a black-grey colour. Both types have a certain sheen or glimmer, especially silver graphite. Care should be taken when using raw graphite powder, as the particles are rather large and when breathed-in can represent a health risk, causing internal scarring in the worst cases. As with all dry powders and pigments, wear a dusk mask when handling.

A common technique with graphite powder, is to rub the raw powder into the surface of the drawing, and then apply a spray fixative. This gives a certain looseness to the working technique, but can present difficulties when fixing, as the spray of the aerosol fixative may dislodge the fine graphite powder. An answer to this may be to prepare the paper support with a solution of egg white (glair). This is done by first whisking the egg white to a froth, then leaving to stand (cover the glass bowl of egg white with a damp cloth) overnight. After leaving to stand for 12 hours, the froth and liquid separate out. Throw the froth away and use the liquid egg white: it contains a high percentage of protein and will thus be less water resoluble than the complete egg white. Apply the egg white liquid with a flat brush to the paper support and leave to dry for 20-30 minutes. After this time, the drawing is made, using graphite rubbed into the paper surface or dispersed into water and brushed on to the surface. When the drawing is complete (no longer than 4-5 hours after the egg white was applied to the paper), the paper surface is fixed by exposing to steam – a boiling kettle can be used for this. This steam-fixing causes the egg white to harden, encapsulating the graphite particles and binding them to the paper surface in the egg white binder. Once dried thoroughly, the drawing surface is fixed and will not smudge unless reactivated with water or more steaming.

Graphite can also be offered in the form of hexagonal sticks, like large crayons. These crayons are simply graphite powder, cooked with clay and then formed into a mould without the wood casing. They tend to be large in diameter (perhaps 2cm wide) and therefore very useful for making expressive marks.



Graphite Crayon

Pencil

Graphite was in former times referred to as plumbago, or black lead, because it closely resembled raw lead pieces and indeed, until the 18th century was thought to be a form of lead. Because of this, pencils are sometimes erroneously called "lead pencils", when they in fact have nothing to do with that odious metal. The first pencils were formed by cutting lump graphite into thin slivers that were then placed between wooden or metal callipers (port-crayon) to form a drawing tool. The same procedure was carried out with other lump materials used for drawing, such as pieces of red chalk or black shale.

The pencil as we know it today relates to a modified form of graphite, where graphite powder has been cooked (calcined) with china clay or kaolin, to form thin but durable rods of graphite. The clay content in a pencil governs its hardness. For example, a 9B pencil will be very soft because it contains virtually no clay, whereas a 9H is very hard because it contains a high proportion. The cooked rods of graphite and clay are subsequently encased in wood, usually soft cedar wood.

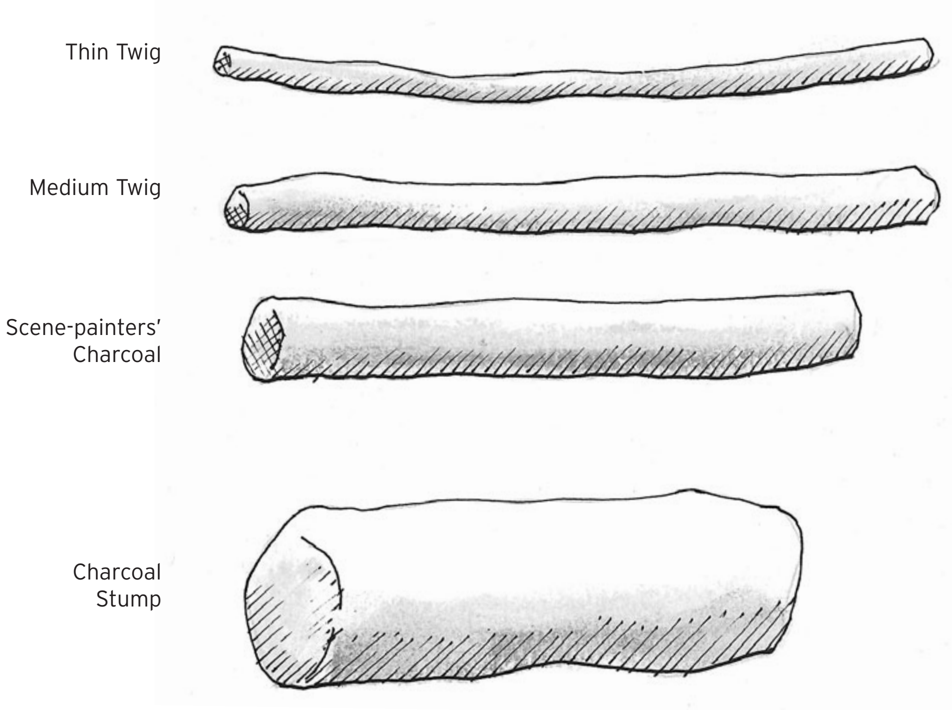
Pencil offers a great number of possibilities, not least because it is such a direct medium: the mark is made in a controlled and direct manner, and by combining different hardness and softness of pencil, a variety of tonal marks can be achieved.

Pencil lends itself well to sturdy, smooth drawing papers, especially when detail is called for. However, experimentation is important: the paper chosen for a soft pencil may not work as well with a hard pencil and vice versa.

Charcoal

Wood that has been slowly charred in an enclosed environment, produces charcoal. During this process, the supply of air is virtually excluded, but just enough is permitted to allow the wood to continue burning slowly. The best drawing charcoal has a velvety feel as it contacts with the paper surface and can subsequently be smudged, or gently taken back, using an eraser, putty rubber or paper stump (a tightly rolled piece of paper, which forms a gentle type of eraser, ideal for making soft tonal marks with charcoal). Charcoal can be made from many different types of wood. Most drawing charcoal is made from charred willow twigs, but other woods such as hazel, alder, poplar and beech may also be used. Harder woods such as oak produce charcoal that is hard and scratchy, requiring the paper support to be first prepared with a toothy ground such as rabbit glue and pumice, as described for graphite.

Charcoal is offered in a variety of formats, from thin sticks for detailed drawing, to wider sticks ("scene-painters' charcoal"), large twigs, blocks or stumps. All give a variety of mark and should be tried on to a number of different paper supports.



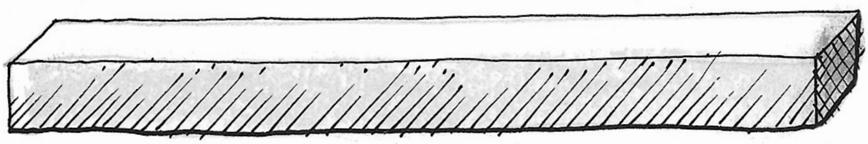
Varieties of Charcoal

Oil Charcoal

When charcoal is soaked in vegetable oil for a prolonged period, it slowly absorbs the oil and thereby gives a greasy, saturated black line when used as a drawing material. Take slow-drying poppy or safflower oil and immerse charcoal twigs/sticks into it, then leave in a closed container for about one week. After this time, each stick is carefully blotted with absorbent paper to get rid of any residual oil and then wrapped in aluminium foil, to prevent the oil drying. Oil charcoal can be applied to any support which has been given a nominal layer of rabbit glue size, or gelatine size. Alternatively, it can be used on to supports that have been acrylic primed. If used directly on to paper, the oil in the charcoal will leech out and stain the paper surface. Oil charcoal will take between one to two weeks to dry out once applied.

Compressed Charcoal

When charcoal is mixed with oil, then reduced to a slurry and fed through an extruding machine, the result is compressed charcoal. This is a dense, saturated black drawing stick which smudges very easily and gives a slightly greasy mark. Compressed charcoal is normally sold in the form of cylindrical or square end sticks. The amount of oil in the charcoal is much reduced compared to that of oil charcoal and as such, compressed charcoal can be applied to any type of paper support.



Compressed Charcoal

Soft Pastel

Soft, velvety pastel sticks make excellent drawing tools: they are supplied in a vast array of delicate tones and have a consistency that is ideal for smudging and blending. They offer a subtlety that is often lacking in other drawing materials. For example, if one uses a range of soft pastel in greys from dark to light, perfect modulation of tonality is possible. Soft pastel can also make a good contrast when applied alongside other drawing media. (For further information, see the chapter on Soft Pastel Painting.)

Oil Pastel

Linseed oil, beeswax and animal fat (tallow) may be used to form oil pastels. By contrast to soft pastel, oil pastels are heavy and saturated in colour terms, but the drawn mark may be rather greasy and difficult to smudge or manipulate once applied. Oil pastel can be applied to glue-sized paper or acrylic primed paper, but with unsized papers, oil pastel can gradually leech out oil into the paper fibres. Another drawback with oil pastel is that the tallow used in some brands leaves a paint film which may be virtually non-drying. Some oil pastels can remain slightly greasy and moist indefinitely. Some brands are based on vegetable oils which have a very long curing (drying) time, perhaps between one to two years; only after this may finished works be framed. If oil pastel paintings or drawings are framed under glass before completely dry, the paint film can remain slightly humid, thereby fogging-up the inside of the glass. However, if the finished artwork were to be left unglazed, it may be susceptible to attack by microbes (in the case of oil pastels containing tallow) and can also attract dust on to the soft surface. One French manufacturer offers a special spray varnish for oil pastel, which protects the applied surface.

Oil pastels are available in a variety of colours and sizes. Check the permanence of oil pastel sticks before purchasing, as some brands may be less stable to light and atmosphere.

Oil Sticks

Linseed oil (or stand oil), carnauba wax and beeswax can be used to form an oil stick, in combination with pigment. These oil or pigment sticks are rather better than oil pastels in terms of use, because they do dry effectively and allow the artist to apply colour directly to the chosen support. As with any oil-containing media, oil sticks need to be applied to primed surfaces. The applied mark remains flexible, so can be used on to acrylic primed stretched canvas, but also glue-sized papers. Oil sticks can be manipulated once applied, by a brush either dry or loaded with paint medium or solvent. In a sense, oil sticks create a bridge between drawing and painting: colour can be applied directly without use of brushes, but can be subsequently manipulated to give changed effects as required. Soft beeswax is combined with a proportion of harder carnauba wax to provide a dry paint film which has a good degree of durability. Any paint/drawing medium containing wax however, is sensitive to heat. Beeswax melts at 62°C, so finished artworks need to be displayed or stored away from heat sources (even domestic radiators) and never displayed in direct sunlight.

Crayon

Square-format crayons, as developed by Nicolas Jacques Conté (1755-1805) in France, are formed by heating pigment with clay (in a similar fashion to that of pencil making). The resultant crayons are harder than soft pastel but can be used in a similar way. These crayons can give harder edged lines and detail, and may form a useful contrast to soft pastel when used in combination. For life drawing, a special range of colours is produced: sanguine, sepia, grey, black and white.

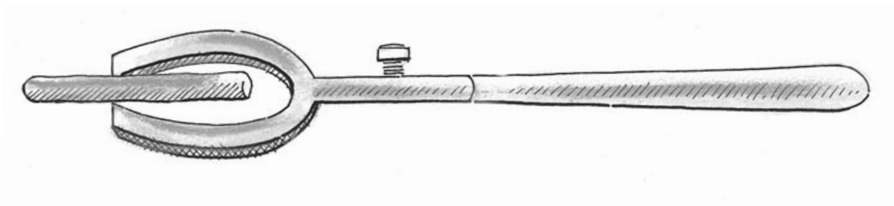
Metalpoint

Silver or other soft metals may be used for metalpoint drawing. By tradition, such drawings are made on to a specially prepared support. Gesso panel can be used, or gypsum with rabbit glue applied to any type of paper. Bone ash is sometimes used in the place of gypsum, or admixed with it in the formation of the gesso ground. Bone ash gives a soft cushion, which reacts well when contacted with metalpoint. On a gesso panel, the drawn mark will appear as a dull grey: the mark made by the soft metal re-depositing itself on to the white ground. With silver, at first the mark is greyish, but over time it tarnishes to a red-brown colour, reminiscent of many Old Master drawings.

Natural Chalks

Coloured earths, usually clays tinted by iron oxides, have long been used as drawing materials. With Old Master drawings, terms such as “red chalk” and “black chalk” are often cited, relating to just such materials. Red chalk, sanguine (the colour of dried blood) is typical of these natural drawing “chalks”, being composed of soft sandstone coloured by iron deposits, changed from yellow to red during exposure to heat from volcanic activity and found in the form of compressed lumps. This sanguine chalk gives out a soft earth-red mark which is easy to smudge. The best quality varieties of this can be carefully sawn into thin slivers and used for making detailed marks. These sawn slivers are best placed into a port-crayon for ease of use. Lumps of raw ochre from the South of France or sienna from Italy, may also be used as drawing tools, giving a soft yellow mark.

Black chalk, from soft shale can be used for drawing and similarly cut to form drawing tips. Natural black chalks are found in many parts of the world. Historically, “Bideford Black” was an important source of soft black cliff chalk from Devon, England.



Port Crayon for Holding Natural Chalks

Calcium carbonate (white chalk) in lump can also be used as a drawing material. Kaolin can be formed into a white drawing chalk, by simply mixing the powdered kaolin with cold water and allowing to set. The kaolin is naturally setting and dries out to form a consistent chalk. Adding a little neat alcohol to the water helps to form a more compressed lump when the material is kneaded together before drying.

Wet Drawing Tools

Inks

Ink is a general term that seems to refer to any drawing medium which is applied in a liquid form.

The simplest form of ink, often used more for writing than drawing, was that made from gall nuts (oak apples). The diseased gall nuts of the oak tree are collected and immersed into water which is rich in iron salts. For example, old rusty nails, left to steep in cold water for a week will suffice. Otherwise, pure iron salts in granular form can be used. The oak galls react with the iron-infused water to produce a deep black with a slight bluish tinge. This iron-gall ink does not require any binder, as the ink itself has a slightly corrosive nature: gently embedding itself into the fabric of the paper support. When kept away from sunlight, iron-gall ink will last and last. However, on exposure to sunlight, it can fade perceptibly. For this reason, inks for drawing tended to be prepared with other raw materials.

Ink Stone

In Chinese art technique, a water-soluble gum is compounded with the black soot from a chimney (the equivalent of modern-day lamp black). The lamp black pigment has such a fine particle size, that the resultant ink paste appears to be very strong and saturated. Traditionally the ink paste is left to dry out in a stone well or reservoir. It forms a hard cake, which only gives back a black colour when re-wetted with water and the surface agitated against the small hard ink stone. The gums used for making such inks were resoluble (e.g. gum acacia, gum tragacanth, cherry gum) and in a sense were very similar to cakes of watercolour paint. In Japanese painting, similar ink stones or sticks are still used today, known as Sumi ink. These vary in intensity of tone and have variations of granularity upon drying.

Ink, with Gum Arabic Binder

Pigments, especially those with a fine particle size, can be carefully mixed with a thick solution of gum arabic to create hand-made coloured inks. These can be diluted with water, but will remain water-resoluble, even when dry on the paper surface.

Indian Ink

Lamp black can be combined with a special binder, which is water-diluting but water-insoluble upon drying. This type of ink is commonly known as “Indian Ink” or “India Ink”. The binder is a mixture of shellac resin, with borax. The borax is gently heated until dissolved in a quantity of water, then shellac is slowly introduced and left to simmer. The resultant syrup provides a water-insoluble binder upon drying. When applied neat, the ink dries slightly shiny: ideally, these inks are diluted during use, so that they dry to form a neutral sheen. Indian Ink and pigmented inks based on this shellac-borax binder can be applied to most paper surfaces, or to gesso panels (e.g. to map out underdrawing with a liquid ink), but are less successful on to stretched canvas, where the shellac forms a very brittle paint film.

Shellac-Borax Inks

This same formulation of shellac-borax can be used with dry pigment to create individual inks of character. This also allows the artist to govern the strength of the ink. Proprietary brands of shellac-borax inks tend to be rather dilute. Many ink ranges in this category are also based (partially at least) on coloration by dyes rather than pigments. As a consequence, such dyes cannot be seen to be wholly permanent. It may be better practice to take a range of permanent dry pigments and prepare them with the shellac-borax binder. The first stage of this process is to wet the chosen pigment on a glass slab. A small amount of distilled water is added to the quantity of pigment used, just enough to create a stiffish paste. This paste is mixed, using a palette knife or glass muller, so that all the particles of pigment are saturated with water. Once this is done, about 30-40% shellac-borax binder is introduced and thoroughly mixed through. The resultant ink-paste can be stored for a week or so in a closed glass container. This brackish ink-paste can be further diluted with water as required while drawing. It should be possible to use such diluted ink with dip pens, cut quills, brushes, or feather tips.

Sepia Ink (from the cuttlefish ink sac)
Bistre Ink (from birch or beech soot)

These two inks have long been used by artists to create deep brown tones. Both are fugitive to light but remain of great interest. Finished works should be kept in closed portfolios and only displayed in subdued lighting. Both can be prepared by mixing the authentic dry pigment into the shellac-borax binder.

Many sepia "tints" or imitations are available commercially, often prepared with fugitive dyes, but none have the subtlety of true sepia ink.

Ink, with Acrylic Binder

Proprietary brands of acrylic-based inks are available, which tend to have a higher gloss when dry than shellac-based inks. However, acrylic-based inks should be far more flexible and, as such, have found favour with many artists who wish to use them on to stretched canvases, perhaps in mixed media techniques. Acrylic-based inks may be presented in very thin, fluid format, where often the pigment content filters out to the bottom of the pot. Before use, such inks need to be stirred to redistribute the contents. It may make more sense to choose strong acrylic paints and simply dilute them with water when required for ink techniques.

Egg Tempera Painting

Supports for Panel Painting with Egg Tempera

Painting supports can be divided into two basic types:

1. **Rigid support; panel, board.**
2. **Flexible support; canvas, paper.**

By tradition, rigid supports are adopted for egg tempera painting, due to the relative inflexibility of the dried paint film. Over time, egg yolk (as a binder) gradually hardens. Although the paint film is extremely durable, it loses what flexibility it may have initially possessed. As a consequence, egg tempera paint, when applied to flexible supports such as canvas, tends to show cracking or flaking to some extent, over time. However, many historical examples of egg tempera painting made on to canvas exist, where careful (i.e. thin) application of paint helps to reduce the degree or likelihood of this cracking/flaking.

The ideal support for egg tempera is a rigid panel or board, carefully prepared in the time-honoured tradition, by laying down many coats of gesso ground. This gesso ground has a gently absorbent surface, which partially sucks the first paint layers into itself, providing a perfect bonding between painting ground and paint layer.

The panels or boards used for egg tempera vary according to source and quality. Modern, compressed fibre boards (e.g. medium density fibreboard) offer a suitable alternative to panels of natural wood. Compressed fibre boards are manufactured from exploded wood fibres, which are mixed with a resin-based glue and put under pressure, thus compacting to form a solid, stable "wood-like" panel. Because heat is used in the compression of the fibres, the surfaces of such boards tend to be flat and smooth. By contrast, the edges of the panels are slightly fibrous, more so when such panels are cut at the wood yard. This fibrous edge needs to be carefully sealed during the priming stage, so that moisture cannot work its way into the panel (which could induce swelling).

The thickness of the panel is crucial: thin panels will tend to warp when the priming ground is applied. Thinner panels may also show a fibrous surface, which interferes with the smoothness of applied painting grounds. By choosing thicker panels (12, 15 or even 20mm), the risk of warping is reduced. However, any larger size panels (for example, larger than one metre square) may need to be braced on the reverse, to prevent warping. Such bracings, made with wooden batons glued to the reverse with strong wood glue, will also increase the overall weight of the panel.

Other types of manufactured panels, such as hardboard (masonite) are less-suited as supports for egg tempera, due to their thinness and subsequent tendency to warp.

Natural Wood

A great many historic examples of panel paintings made with egg tempera have survived, executed on to various types of natural wood. With the benefit of hindsight, it can be seen that some of the woods chosen for painting panels have shown remarkable defects. For example, the Italian painters of the *quattrocento* made extensive use of poplar wood as their painting support. Poplar is a very fibrous, absorbent wood, which quickly takes up moisture in damp conditions. As a consequence, many panel paintings from this period exhibit cracking within the paint film; the wood itself has swollen and contracted over time, thereby exerting pressure on to the paint film. By contrast, in Northern Europe, painters worked on harder panels, constructed from oak, which do not absorb moisture so readily. Such hard-quality panels were often used by Rubens, for example. His panel paintings show remarkably few cracks or imperfections that relate to the support.

Natural wood is always prone to moisture. As a consequence, wood used to make painting panels should be thoroughly dried (seasoned) before use. This drying process necessitates that the wood be air-dried for a long period (1-3 years) in a stable environment.

It is also important that the wood is cut in the autumn (when it is most dense in structure), rather than at other times of the year. In particular, wood cut in the spring will be more "open" to moisture than that cut in the autumn.

In practice, painters would benefit by locating specialist wood suppliers (e.g. for cabinet making) rather than bulk wood merchants.

Preparation of the Panel, Prior to Applying the Gesso Ground

Before applying any priming material, wooden panels or boards should be degreased thoroughly. During handling and cutting, greasy residues are often transferred on to the panel surface. These will inhibit the application of sizing and priming layers.

Ensure that the sides of the panel are relatively smooth. Gently sand down any fibrous residue from the sawing process. It is not advisable to sand the surface of the panel, as this will open the pores of the wood. When sizing/priming (i.e. moisture) is applied to such a surface, it will tend to increase the chances of the panel expanding. A soft, lint-free cloth is used to wipe the panel of any dust or loose fibrous residue. Another cloth is then soaked with a little methylated spirit (alcohol) and wiped over the board surface, its sides and reverse. This treatment will dislodge any small greasy residues. The panel will need to be left to dry after this treatment, before application of the priming material. During this process it may help to sit the panel on small wooden blocks, so that it is raised off the ground, allowing air to circulate.

It is always advisable to prepare a series of panels at one time, so providing consistency from one support to another. Start by preparing six smallish panels, using the same treatment. This saves time and provides a uniform and coherent end result.

Application of the Painting Ground

The traditional ground for egg tempera painting is referred to as "gesso", usually a combination of animal skin glue with a type of chalk. The term originates from Italy, being the Italian word for gypsum. In simple terms, gesso painting grounds fall into two basic types:

1. Gesso ground, based on gypsum (calcium sulphate).
2. Chalk ground, based on whiting chalk, or champagne chalk (calcium carbonate).

The gesso ground (gypsum) tends to be found on old paintings made in Italy (south of the Alps), while chalk grounds (whiting, champagne chalk) can be found in old paintings made in Northern Europe. This generalisation is somewhat confused due to the movement of artists between Italy and the rest of Europe, although until the 20th century, most artists used only materials that were available locally. By contrast, artists working in the first decade of the 21st century have access to virtually any type of material imaginable. This practice is perhaps best seen in the United States, where the use of historical artists' materials (especially painting grounds) still follows the European tradition. An artist working in New York for example, will be able to find all the traditional materials of the Renaissance, through specialist art supply stores. This could include animal hide/skin glues; Bologna chalk (an original type of gypsum) and even horsetail plant which can be used as an abrasive, in the place of modern sandpaper.

The chief difference between gypsum (calcium sulphate) and chalk (calcium carbonate) relates to the degree of absorbency. Gypsum grounds tend to absorb paint films evenly; the applied paint film gently percolates down through it. By contrast, grounds prepared with chalk-based gesso tend to absorb applied paint slightly unevenly, with a sponge-like effect. As a consequence it can be easier to gain regular, even paint films with gypsum based gesso grounds.

Glue

Traditionally the glue used for applying gesso on to panels is based on animal skin. It is sometimes referred to as "hide" glue. Good quality modern skin glues (for example rabbit-skin glue) differ from the glues of earlier periods in that they are clean (refined) and swell very quickly when soaked in cold water.

Recipes from the 1300s and 1400s mention the use of parchment clippings (the waste from the production of goatskin vellum parchment, used for illuminated manuscripts). Goatskin parchment clippings have to be soaked for at least 24 hours before they begin to swell. Similarly, in former times, skin glues were prepared in the form of thin sheets. These need to be soaked in cold water for about 24 hours before they swell. By contrast, some high quality, clean, modern glues will swell in 30 minutes.

In some cultures (Russian for instance), other glues were commonly used for preparing panels. Isinglass, a glue made from the swim bladder of the Russian Sturgeon is a good example. As with parchment clippings from goatskin, isinglass produces a very pale, almost clear glue, which is somewhat less-prone to darkening than animal skin glues. Although glues such as isinglass and parchment clippings are more difficult to find in today's market, artists may wish to consider using them, not only because of their pale colour, but also because they remain very flexible over time. For example, isinglass is often used as an adhesive in the repair or conservation of textiles, where a great degree of flexibility is required.

The quality of animal skin glue available to artists today is a matter of some concern. Where possible, artists should use glues that are clean, free of waste products and which swell readily. Modern glues tend to be sold in the form of grainy powder, or small rough granules. An easy test for the quality of a glue is to place a quantity of it into a glass jar. Fill the jar with clean, cold water and allow the contents to settle for a few hours. If any debris forms on the surface of the water, this is an indication that the glue may include foreign matter.

In some cases, glues have a dark brown appearance in their dry, powdered state. This can also be an indication that the glue is dirty. Ideally, animal skin glue should form an almost clear solution, perhaps with a very pale straw colour. If it is orange-brown, or has a residual scum on the surface, it may not be of the best quality.

The strength of the glue is a further consideration, which is the cause of much consternation among artists of a discerning nature. In the furniture-repair trade, animal bone glues are often employed. These need never be considered for use in painting, as they tend to be rather dark in colour and quite inflexible. However, these glues are sometimes sold to artists for sizing canvas, preparing panels, etc. It is important that artists wishing to work using refined techniques (such as tempera, oil painting), check the quality of the materials they intend to use prior to use, in order to facilitate the best possible outcome for the proposed artwork.

In relation to this, the ideal glue for preparing gesso on to panels needs to be:

- Flexible
- Clean
- Pale in colour
- Sufficiently strong to adhere the chalk/gypsum to the panel surface.

An additional factor when considering glue, is to remember that such natural products are prone to fluctuation. As a consequence, the exact quality of a glue may change from batch to batch. Because artists tend to use very small amounts of these raw materials at any one time, it is quite possible that in the time period between one purchase and another, the quality of a product could fluctuate. As a consequence, it is unwise in the context of this book to give an exact recipe for making glue, because the relative strength of a glue can vary from one supplier to another, and also between time periods.

For panels, the strength of the glue may be higher than that used for the sizing of canvas. Rigid supports such as wooden panels tend to flex to a lesser degree and less often than would be the case with stretched canvas. As a consequence, it is suggested that for panels, the glue can be prepared with less water than one would use for a glue being applied to canvas.

The following recipe, as already stated, relates to one particular brand of animal skin glue. It may be necessary to adjust the recipe according to the nature of the glue being used.

Standard Recipe for Animal Skin Glue (for Panels)

Animal skin glue	1 part
Cold water	15 parts

The glue, usually supplied in the form of a rough powder, or grains, is measured (e.g. with a spoon) and placed into a clean glass vessel. The required amount of cold water is slowly introduced, then finally stirred, so that all the glue is covered and wet. The glue tends to sink to the bottom of the vessel. Leave this mixture to stand for at least 30 minutes. Stir once or twice, to distribute the glue in the water; if the glue is left unstirred, it tends to clump together. After 30 minutes, the glue will have swollen in the cold water to create a mushy paste.

In order to form this into a solution, it requires warming. During this process, the glue changes from a slightly opaque/frosty paste to a clarified, translucent liquid. It needs to be warmed through very carefully. Ideally, the glue is applied to the panel surface when it is still warm, if it becomes too cold, it will turn back to a firm jelly. The best way to warm the glue, is using a hot water bath. Firstly boil a kettle and pour its contents into a large pan. The glue vessel is then placed into this hot water bath: after 1-2 minutes, the glue should be sufficiently warmed to form a clarified solution. The hot water bath will stay warm enough to retain the glue in solution for another 10-15 minutes. If the glue has started to set into a jelly, simply replace the hot water with more boiled water. In this manner, the glue can be kept warm but not too hot.

The worst method for warming the glue is to keep the vessel it is in over a direct heat, or in a double boiler placed on a direct heat. If the glue is heated too much, the water content will be driven off and as a consequence, the glue will become stronger and stronger. When layers of glue are applied with different strengths (e.g. a strong layer over a weak layer), a discrepancy in the relative tension of each layer is created. In the worst case, this leads to warping of the panel, or could cause one layer (of gesso) to pull away from the layer on to which it has been painted.

A good way to check the strength of the glue is to warm it through, then leave it to cool and set to a jelly. When the jelly is parted by forcing it to break between the thumb and forefinger, it should ideally collapse slightly (giving an "apple-sauce" consistency). If when parted, the glue jelly cleaves cleanly, it is a sign that it is overstrong. If one feels that the glue is too strong it can be re-warmed with a little more water added. Keep a note of the recipe used for each batch of glue.

Another factor relating to glue is atmospheric condition. In hot weather, glue will stay in solution more readily than in cooler weather. In the northern hemisphere, glue will tend to cool rapidly in the winter, especially if one is working in a large, un-heated studio space.

Preparing the Panel with Gesso

The procedure for applying the ground, whether using gypsum or chalk, is essentially the same. A first "grip" coat is applied to the panel surface, followed by a series of between 4-10 coats of gesso.

The grip coat consists mainly of glue, with a pinch of gypsum or chalk (about 10% dry powder to 90% volume of liquid glue). This small addition of gypsum or chalk provides a key to which further coats can attach themselves.

The first coat is applied to the face of the clean panel and allowed to dry. Some artists choose to apply the grip coat and subsequent coats to the sides and reverse of the panel, at least in the first few layers. This seals the vulnerable edges of the panel, and coats applied to the reverse help to equalise tension across it. However, on examining many panel paintings over the years, made during different time periods, the author suggests that this practice of gessoing the sides and reverse is a modern fashion and largely unnecessary.

The grip coat also seals the pores of the wood, so that subsequent layers of gesso can be laid down evenly and smoothly on to the equalised first coat. With all primings, the first coat laid down has some influence on subsequent ones. If the first coat is coarse, then following coats will repeat the unruly pattern, providing an incoherent, bobbly surface. If the grip coat contains only a small amount of gypsum/chalk, it will be enough to form a key with the next coat but will not interfere with the smoothness of the priming.

Once dry, the grip coat is overlaid with subsequent coats of gesso (gypsum/chalk with glue). Again, there are many recipes for making gesso: it is advised that the following standard recipe is used and then changed according to the requirements of the artist and the type of surface.

Recipe for Gesso

Gypsum	1 part
Liquid glue	1 part

Always add the gypsum (or chalk) to the glue, never the other way round. An equal volume of liquid glue to gypsum is a good starting point. The gypsum is lowered into the glue and allowed to fall beneath the surface, spoon by spoon. Allow the gypsum to absorb into the warm glue slowly and by its own gravity. Try to avoid stirring, as this will introduce unwanted air bubbles into the mixture. The best method is to deposit the gypsum into the glue and leave it for 15-20 minutes, until it all falls down to the bottom of the vessel. Do not worry if the glue cools and forms a jelly during this period. It can be readily re-warmed, by replacing in a hot water bath.

When ready to apply to the panel surface, stir very slowly (again, to avoid air bubbles), to distribute the gypsum within the glue solution. The gesso should have the consistency of single cream: if too thick, dilute slightly with some warmish water and stir slowly before using. The gesso is applied to the panel using a 4-5cm width flat hog-hair brush (regularly sold as varnishing brushes). Dip the brush into the gesso mixture, slowly draw it against the side of the vessel, so that only a small amount of the liquid is retained in the brush. Again, this helps to free air bubbles. The gesso is then applied to the surface of the panel, working quickly but carefully over the whole panel in one direction, and carefully wiping back any residue at the panel edges, with the brush. Allow the first coat to dry for 10-15 minutes before applying a second. Allow each coat to dry before putting on the next, in this way, between 4-10 coats can be applied to build up the priming surface. The number of coats applied is a personal decision but remember that the greater number of coats, the greater the tension across the panel from the glue.

Once all the coats have been applied, the panel is left to dry for a few hours, so that all dampness has gone from the panel and the gesso layers. Preferably leave overnight to dry out thoroughly.

Once dry, the gesso surface can be sanded to a smooth, ivory-like finish. Choose finer, rather than coarse sandpaper, or use dried horsetail plant. The stem of the horsetail is cut in half and flattened, then slightly dampened. This causes the plant fibre to swell slightly and, because the texture of the stem is abrasive, it can be used in place of sandpaper.

It is also possible to sand the gesso between each dried layer. This will ensure a very smooth surface between each layer and make the final sanding easier.

If air bubbles formed during the laying down of the gesso, this usually indicates that it was too hot when applied, or that air was stirred into the mixture. Through practice, such annoyances can be eradicated.

The recipe above relates to the use of fine gypsum mixed with glue. In many historical texts, other grades of gypsum or chalk are mentioned. In Italian technique for example, there are two basic forms of gypsum used for preparing panels:

1. *Gesso grosso* - larger particles, giving a rough surface.
2. *Gesso sottile* - very fine particles, giving a smooth surface.

By tradition, the gesso *grosso* would be employed for the first coats, especially where two panels were to be joined together, or faults in the wood had to be disguised. The larger particles would form a thicker cushion, over which the gesso *sottile* would be applied. Nevertheless, the gesso *grosso* would need to be abraded to give a smooth finish, once the joints or discrepancies in the panel were covered over. In some cases, it was used in conjunction with strips of linen cloth, employed to cover over joints between panels. The gesso layers would be used to adhere the linen cloth to the panel and then overpainted with subsequent coats, until the linen was not visible.

Modern gypsum and chalk is sold according to a mesh number. This relates to the size of the mesh used when sieving the raw material. The smaller the mesh number, the finer the grains of gypsum/chalk. The finest grades are also used by gilders, for the preparation of gilding grounds and are therefore sometimes referred to as "Gilders' Whiting", or "Gesso *d'oro"* (gesso for gold).

As already mentioned, it is wise to prepare a number of panels at any one time for the sake of consistency.

Preparation of Pigments for Egg Tempera Painting

Tempera painting relies on the mixing of pigments (colour) with a water-thinnable binding agent. Upon drying, this binding agent becomes insoluble and permanent. However, while damp, or very recently dried, it is possible to rework the paint film. The term "tempera" may refer to the notion of "tempering" colours prior to painting. Within the fresco painting technique, colours are simply mixed in water and applied to a wet ground of plaster. This plaster, being composed of fast-setting lime, fixes the water-borne pigments to the painting surface (typically a wall structure). In this way, with fresco painting, colours are never mixed with a binding agent, rather they are attracted to the wet plaster surface, which in effect acts like a cement: attracting the pigment particles into a fixed position.

By contrast, with tempera painting, pigments are specifically mixed with a binding agent prior to application to the painting support (usually a gessoed wooden panel). This process can thus be referred to as the tempering of colour, in readiness for painting.

Egg is the most famous of these binding agents and the terms "tempera" and "egg tempera" have become inextricably linked. However, other forms of tempera paint exist and require some discussion. Among the other water-based binding agents sometimes referred to in the context of tempera painting are:

Gum tempera	gum arabic, dextrin, or gum tragacanth solutions (plant protein binders), mixed with pigment (see Gouache Painting section)

Glue tempera	animal skin glue, or isinglass (fish glue), mixed with pigment and applied as a paint, while kept warm
Casein tempera	curd cheese (or dried "skimmed" milk), mixed with pigment
Glair	egg white, mixed with pigment.

Egg Yolk as a Binder

The characteristic finish of an egg tempera painting has a low, slightly glossy sheen. The binding agent responsible for this is egg yolk, a natural protein-rich emulsion: a mixture of albumen, water and fatty oils. This slightly greasy substance has a characteristic warm yellow colour and a certain viscosity. It can be readily diluted with water to form a thinner consistency as required. As already mentioned, once thoroughly dry, egg yolk paint films become extremely hard and durable and remain water-insoluble. There is a window of solubility, perhaps somewhere between one and six months, when the paint surface can be disturbed if thoroughly agitated, prior to complete curing (drying).

Preparing the egg yolk for tempering with pigment is an important procedure: the white of the egg must first be removed, followed by the sac of the yolk, so that only the liquid portion of the yolk is retained for use. After cracking the egg and separating the white from the yolk by carefully passing from one hand to another, pinch the yolk in its sac between thumb and forefinger and carefully slice the sac with a scalpel. Collect the liquid yolk, which will slowly drain out of the sac, into a clean glass or ceramic vessel. It may help to strain the liquid yolk through a fine sieve to remove any other debris.

The resultant yolk is ready to use for painting, although it is a good idea to add between 30-40% cold water to reduce the consistency.

This allows the yolk to flow freely and mix more readily with the dry pigments. When water is added, the yolk becomes cloudy/milky in appearance. This cloudiness disappears upon drying to reveal a thoroughly translucent paint film.

Because egg yolks decompose rapidly, it is advised not to mix up quantities of pigment with the yolk. Far better practice is to prepare the chosen pigments with purified or distilled water, making them into stiffish pastes. These damp pastes can then be incorporated with the egg yolk as and when required for painting. It is wise only to prepare enough egg yolk for each painting session. After 1-2 days, the yolk will begin to give off an odious sulphur smell.

The character of the eggs used in painting may also be of some influence. Factory-laid eggs may be pale in colour, or weak and watery in consistency. By contrast, farm eggs tend to be very warm in colour and thick in consistency. It is preferable to work with freshly laid eggs that are free from any additives or colourings.

Before painting, each chosen pigment needs to be mixed with purified or distilled water, rather than mineral-containing tap water, which can react with some delicate metal-based pigments (e.g. genuine naples yellow). Another possibility, is to mix the pigment with pure alcohol (methylated spirit). The alcohol rapidly saturates the pigment particles but will quickly evaporate. Better practice is to make a mix of part alcohol, part water, which gives a more balanced paste. Alcohol as a wetting agent is very useful for certain pigments, namely those with a very small particle size. Normally when such pigments (e.g. alizarin crimson) are mingled with water, the water does not readily mix. The addition of a drop of alcohol into the water helps to break water tension, so that the water-pigment paste can be prepared. Older recipes call for the use of spirits of wine to perform this wetting task, but industrial methylated spirit (water-clear), or denatured methyalted spirit (which has a pale pink or violet colour) are readily available today.

The procedure for making the water-pigment pastes is as follows:

On a glass slab (with a sand-blasted surface, which catches the pigment particles and prevents them from dancing across the surface), grind the required amount of pigment with a tiny amount of purified/distilled water. Add enough water to create a stiff, brackish paste, using a straight palette knife for mixing. Take this paste as a whole, or divide it into small portions, and begin to mix it thoroughly using a glass muller (also known as a glass runner). This, is a round, heavy glass “paper-weight” shaped object, sometimes with a tall glass handle, or perhaps a doorknob style handle.

It is used to mix pigments thoroughly into binding agents, or in this case, with water, so that all the particles are divided and saturated by the water. This process ensures a smooth paint film. In fact, the more the pigment is mixed in this way, against the glass plate, the better the colour may be. It is normal to move the glass muller across the glass plate in a figure of eight motion, trapping the particles under the muller and forcing them to combine into the water, to divide from each other (to stop clumping together) and gradually to form a smooth paste. As one proceeds, it may be useful to add a few more drops of water to lubricate the mixture, but beware of adding too much as this could give a sloppy consistency. If pigment catches on the edge of the glass muller, reposition it with the palette knife back on to the glass plate, so that it can be reworked. It is easier to work with small amounts of pigment at a time, than to try and mix everything at once. There is no need for excessive force when using the glass muller: it is merely a case of introducing the pigment into the water, then, once it is freely moving around in the water, the glass muller should move easily over the glass plate. Once a smooth paste has been achieved, where all the particles are saturated with water and forming a coherent paste, put this into a small air-tight glass jar (e.g. 60ml). In this form, the pastes can be stored indefinitely. If they should dry out, re-constitute the pastes with a little more purified/distilled water and remix on the glass plate, before using for painting.

When ready to paint, put a little bit of the water-paste out on to the palette. A glass plate works very well as a palette, with a sheet of white paper underneath to give an accurate colour reading. Alternatively, a ceramic palette or ceramic plate could be used, or a slab of marble.

Into the water-paste, add a small quantity of the slightly diluted egg yolk binder. The exact amount will be different for each pigment, according to its particle shape and size. For example, some earth pigments (e.g. green earth) have large, irregular forms and as such need more binding agent than pigments with a regular, small particle form. Make test paint-outs of each colour before painting properly. When the test paint is dry, it should ideally be sleek, slightly glossy and provide a smooth, even coating on to a well-prepared gesso panel.

If the mixture contains too much egg yolk binder, it will be over-glossy and fat-looking, with a warmish hue, due to the yellow colour of the yolk (most noticeable when used with whites, yellows and pale blues). If the mixture has too little egg yolk binder, the surface will look rough, matt and chalky. Too little binding may cause the paint film to lose adhesion to the support. Getting the pigment to egg yolk ratio right is crucial with the first coat of paint. This is because the gesso ground has a gently absorbent quality which is highly desirable for tempera painting: the first coat percolates into the painting ground and forms a bond within its structure. It also equalises the surface of the paint film, so that subsequent coats lie flat and even.

If the paint mix is too egg yolk-rich, it may be possible to dilute the mixture quickly with water to gain an even finish. In practice, it takes time and patience to learn the exact mixtures of binder to pigment paste for each colour.

The paint is traditionally applied with small, soft hair, brushes. Kolinsky sable is purported to be the best hair for such painting: it is soft, subtle, yet has great resilience and also a natural "spring" to its tips, which helps to retain its shape. For painting, round tipped brushes are commonly used, but for larger, flat areas, filbert or flat sables are sometimes employed. It is also possible to paint egg tempera using other soft, hair brushes such as those made with ox hair, or even synthetic filament brushes.

The paint is applied in small hatching strokes, whereby form is gradually built with many applications of small amounts of paint. However, there is no exact formula for tempera painting, rather a conflict of styles and applications, often seen within the same painting. In order to obtain the best results with this paint-type, remember that the egg-yolk has a wonderfully translucent effect upon drying, which makes it ideal for making intricate, delicate glazes, or shifts between colours.

During the *quattrocento* period in Italy, the technique of egg tempera painting was refined beyond the confines of Byzantine painting. In part this was due to a more exacting method of preparation in the gesso layers, but also to the fact that the Italian painters did not varnish their tempera paintings in the same way as the Byzantine artists. In the Byzantine technique, an oil varnish (referred to as "Olifa" in many texts) is painted over the finished work. Such varnishes are often composed of a drying vegetable oil (e.g. linseed oil) which has been cooked with a metallic drying agent such as lead acetate. This oil varnish layer saturates the colour values and unifies the painting, with a warm, glowing effect. However, over time, the varnish layer discolours, turning a warm, dark brown, which may obscure some finer details. In many Italian paintings, this oil varnish layer is not applied, or it appears as a very thin veil of varnish, most often made without any oil in the mixture (e.g. a solution of a tree resin such as sandarac into alcohol, providing a very thin, almost colourless but slightly glossy sheen). It is difficult to generalise about such practice but it is obvious to see that egg tempera paintings made without the addition of heavy varnishes over the painted surface retain a clarity, lucidity and freshness, which is difficult to imitate in any other technique.

Palette for Egg Tempera Painting

In the context of egg tempera painting, perhaps more than with other media, it is possible to work with historic pigments. This is because only small quantities of pigment tend to be used, worked up in a careful manner. In other words, costly mineral pigments such as azurite and lapis lazuli tend not to be wasted when working with egg tempera. It is an exacting medium, calling for a measure of patience and careful use of materials. As a consequence, many historic (some would argue obsolete) pigments are mentioned here, along with notes on their use in the context of tempera painting.

List of Historic Colours

This basic list of colours for tempera accords to those pigments mentioned in "The Craftman's Handbook" (*Libro dell'Arte*), by Cennino Cennini (original manuscript of 1437) – see Bibliography.

Lead tin yellow, type I

Lead tin yellow, type II - Soft, pale yellow, for highlights, type I is milky and opaque. Type II is coarser and warmer in hue, based on a silicone matrix which affords some transparency. Toxic, contains lead.

Stil de grain - a warm, transparent yellow, for glazing over blues to make greens. Fades in sunlight.

Orpiment - bright, solid yellow, coarse texture. Toxic, contains arsenic.

Yellow ochre - milky, opaque earthy yellow, varies in shade according to source.

Raw sienna - translucent earthy yellow, for glazing.

Lead red - opaque red-orange, blackens on exposure to atmosphere. Toxic, contains lead.

Realgar - yellow-orange, opaque, coarse in texture. Toxic, contains arsenic.

Madder lake - warm crimson, transparent. Often glazed over vermilion to deepen red shade. Fades in sunlight.

Carmine - coldish crimson, transparent. Often glazed over vermilion to deepen red shade. Fades in sunlight.

Red ochre - earth red, milky, opaque.

Venetian red - earth red, with pinky shade.

Burnt sienna - warm red earth, highly transparent.

Morellone (haematite) - strong red-violet earth. Added to white for pinkish tints.

Vermilion - solid red, opaque, bright red. Toxic, contains mercury/sulpher. Available as mineral (coarse texture) or processed (smooth texture) types.

Red jasper - coarse textured pink-red from mineral rock.

Raw umber - greenish tinge, opaque.

Burnt umber - deep warm brown, transparent.

Verdigris - needle shape particles. Not to be mixed with egg yolk. Prepare instead with just warm animal glue. Discolours over time, to give brownish tinge.

Malachite - pale cold green, from mineral rock. When pulverised to small particle size becomes extremely pale in tone.

Green earth - very transparent, cool, olive green. Needs a lot of yolk binder to work successfully but consequently tends to have a greasy, slimy presence.

Ultramarine ash - coarse texture, very pale blue. By-product of lapis lazuli. Often used for underpainting, before working on top with more expensive blues.

Lapis lazuli (natural ultramarine) - costly pigment derived from lapis lazuli mineral rock. Coarse texture, with violet tinge. Often used over base coat of ultramarine ash or azurite.

Azurite - from mineral rock, coarse texture, with greenish tinge.

Indigo - dark cold blue from plant source. Often used admixed with yellows to give green. Transparent.

Vine black - neutral black, very transparent.

Lamp black - blue-black, very transparent..

Lead white – heavy texture, makes fattish paint paste. Only white available pre-1700s.

Flesh Tints

For flesh tints, a series of mixtures are commonly used, as follows:

1. "Verdaccio". Underpaint for flesh tint. Either a) green earth, or b) verdaccio is applied as an underpaint for further flesh tints. Verdaccio is a mixed colour, sometimes made with raw umber, yellow ochre and vine black, or simply using a raw umber with a greenish tinge. This verdaccio is also sometimes admixed into a series of intermediary tints with lead white.

2. "Cinabrese". Overpaint for flesh tint. Either a) cinabrese made with vermilion and lead white, or b) cinabrese made with a red earth (e.g. haematite) and lead white. Sometimes such mixtures could include both vermilion and a red earth, with white. The cinabrese flesh tint overpaint is strongly diluted with binder and water until it shows some transparency. When applied over the verdaccio underpaint, some of the green colour can be seen through the semi-transparent cinabrese layer. This gives a two

tone effect, similar to the composition of flesh as seen when observing the back of one's hand.

Modern Colours for Tempera

A comparative selection of modern pigments suitable for egg tempera.

O Nickel titanium yellow

T Intensive yellow

O Cadmium yellow

O Iron oxide yellow

T Transparent iron oxide yellow

O Cadmium orange

O Cadmium scarlet

T Quinacridone pink

T Quinacridone red

O Iron oxide red, light

O Iron oxide red, middle

T Transparent iron oxide red

O Iron oxide violet

O Cadmium red

O Cadmium brown

O Iron oxide brown light

O Iron oxide brown dark

T Phthalo green

T Viridian

SO Chrome oxide

T Ultramarine blue

SO Cobalt blue

T Prussian blue

SO Spinel black

T Lamp black

SO Zinc white

For verdaccio: chrome oxide green+iron oxide brown light+zinc white

For cinabrese: cadmium red+zinc white

T = Transparent

O = Opaque

SO = Semi-opaque

Procedure for Painting

With tempera painting, a set series of applications may be followed. While this procedure may not suit all artists, it is a worthwhile exercise to undertake in order to familiarise oneself with the medium of egg tempera.

1. **Gesso ground**
   The surface is smoothed with sandpaper to an ivory-like finish. By tradition, this can be done by dusting the surface with fine charcoal dust. After sanding, when the surface is level, all the charcoal dust will have been sanded off.

2. **Charcoal cartoon**

   On to the smooth gesso ground, a cartoon, or drawing can be made using charcoal, but not fixed. In this way, the composition can be established and re-worked easily by dusting off.

3. **Ink cartoon**

   The charcoal cartoon is gently dusted with a soft brush, or feather, so that only a trace of the drawing is visible. Over this faint design, the cartoon is re-established using a permanent ink, such as Indian ink, diluted to give a pale grey wash.

4. **Coloured glaze**

   Over the "fixed" ink cartoon, a glaze can be applied, using a transparent pigment mixed with the egg yolk binder (e.g. green earth).

5. **Flesh tone - verdaccio**

   The green underpaint for the areas of flesh can be applied, bound with egg yolk. The colour can be solid or transparent as required. This verdaccio layer can be used to create form and depth within the flesh areas.

6. **Flesh tone - cinabrese**

   Over the verdaccio, a semi-transparent veil of cinabrese is applied, to confirm and embellish the form already made with the verdaccio underpaint.

7. **Painting in general**

   Other areas are completed with flatter applications, sometimes overpainted with glazes or details, as required.

Tempera and Oil Paint, Egg-Oil Emulsions

Tempera makes a perfect underpaint for oil painting. If one were to work straight on to gesso panel with oil paint, the first applications of oil colour would readily sink into the absorbent gesso surface, leaving the applied oil colour extremely lean, matt and perhaps even underbound. By contrast, if a tinted ground is painted in egg tempera on to a smooth gesso panel, it provides a well-balanced support surface on to which oil paint can be applied. The first layer of oil colour on to such a ground would only slightly absorb into the tempera layer, but enough to form a good bond between paint layer and ground.

Consequently, many examples of oil paint over tempera underpaints can be found in paintings of the past. Indeed, even though tempera is perceived to be too brittle for use on to stretched, flexible canvas, there are many examples of paintings made in this way, which have been overpainted in oil colour. Sometimes artists worked directly on top of an egg tempera underpainting, at other times a form of emulsion was made, between egg and oil. This provides a more flexible, glossier paint than straight oil colour, but with the advantage of being water-diluted. As with normal tempera painting, the binder will spoil after a few days, so colours need to be prepared and used within the same painting session. It may be possible to keep the emulsion in a refrigerator for a few days, but the ingredients soon start to separate and are never quite the same when they are remixed.

Formula for Egg-Oil Emulsion

Whole egg (yolk/white)	2 parts
Linseed oil (with drying agent)	1 part

Break the shell of an egg(s) and put the liquid contents into a glass vessel. The egg is shaken until completely intermingled and then poured through a sieve to get rid of any waste material. Put the quantity of egg(s) with half the amount of linseed oil. Ideally this should be linseed oil with a drying agent such as cobalt siccative, sometimes referred to as "linseed oil varnish" (the modern equivalent of "Olifa", as previously mentioned). The resultant mixture needs to be shaken so that it forms an emulsion, to which water can be added (up to about 40%) to create a dilute consistency. This will dilute further when brushed out with water.

Pigments can be mixed directly with this binding agent and diluted with water as required. By contrast to normal egg tempera, the paint film is slightly thicker and glossier. If required, thin dammar varnish or mastic varnish can be added to the egg-oil emulsion to create an enamel-like finish. Although this emulsion is more flexible than normal egg tempera, it is not as flexible as oil paint. Once a painting has been begun with this egg-oil emulsion, one must continue to use it on all subsequent layers to avoid cracking.

There are many variations on this recipe which may be worth investigating. For example, walnut oil is often used in place of linseed oil; it has a glassy sheen and is very hard-wearing. Walnut oil is also a paler oil than linseed oil, so may be useful when painting in egg-oil emulsion using pale colours.

Varnishes for Tempera Paintings

Whenever a varnish is applied to a matt paint film, the sheen is radically altered. With egg tempera, the finished paint film has some gloss, but this is not excessive. If a varnish is applied, it tends to saturate colour values (i.e. deepens them), because the tempera paint film is slightly absorbent. Working with proprietary brands of varnish may be a mistake with tempera painting, because they tend to be too thick, or too glossy. By contrast, if one takes a glossy varnish and dilutes it with the appropriate solvent, a fine, thin film of varnish may be applied, which acts to protect the painting surface from dirt, dust, and atmospheric pollutants. However, the best policy may be to leave tempera paintings unvarnished, to preserve their unique presence.

Varnishes – Historic

Shellac flakes, solved into pure alcohol	(pale yellow-orange colour)
Sandarac resin, solved into pure alcohol	(very pale straw colour)
Mastic resin, solved into pure alcohol	(pale straw colour)
Egg white (glair)	(colourless, but turns "frosty" after a few years)
Cooked linseed oil ("Olifa")	(red-brown colour, becomes darker with age)

Varnishes – Modern

Dammar varnish, solved into turpentine	(pale straw colour)
Ketone resin, solved into white spirit	(colourless, may yellow slightly with age)
Paraloid B-72, solved into shellsol A	(colourless, may yellow slightly with age)
Plexisol P 550-40, solved in white spirit	(colourless, may yellow slightly with age)

The practice of tempera painting is at times slightly confusing, because traditionally certain colours are not applied bound in egg yolk, but with other binders such as size, glair (egg white), or in varnish form.

To follow, some examples of colours that are often found in egg tempera paintings but which may not be bound in egg yolk:

Verdigris - bind with animal glue size, or isinglass
Dragon's blood - dissolve into pure alcohol to make a coloured resin varnish
Gamboge - dissolve into pure alcohol to make a coloured resin varnish
Pale blues - sometimes bound with glair (egg white)

The inclusion of such colours gives a particular dilemma when considering which varnish to apply, as some of the colours would re-dissolve if varnished over. For example, if one were to glaze shellac varnish over a layer of dragon's blood, the dragon's blood, being sensitive to alcohol, could re-dissolve.

Some modern varnishes may offer a good solution in that they can be diluted to extremely thin films, almost to the point where they give no perceptible change in sheen to the surface of the painting. In dilute solutions, varnishes such as paraloid B-72 can also be spray applied, thereby avoiding any mechanical contact with the painting surface.

Tempera and Gilding

Gold as a colour has played a very important role in the history of Western art. Principally, gold signifies a heavenly, celestial space. It is therefore found in backgrounds/backdrops to many sacred paintings, especially during the Italian Renaissance. Gold is normally applied alongside egg tempera in the form of extremely thin leaves of gold. Because gold as a metal is extremely soft and malleable it is possible to beat small pieces of it into very fine sheets or leaves. This "gold leaf" can also be applied on to gessoed panels, to give an impression of solid gold colour. The gold leaf is applied over a special ground, known as "bole". This is similar to gesso in that it is formed principally of animal skin glue mixed with a coloured pigment. To impart softness to this special bole ground, an addition of china clay or kaolin is added to the glue-pigment mixture. Other softening agents may also be included. Graphite was extensively used in English gilding as a sure-fire method to achieve a smooth polished surface. The mix of bole is applied over the smoothed gesso surface, usually in 2 or 3 coats. The first coat may be a yellow colour – yellow ochre or raw sienna – followed by 1 or 2 coats of red, made with a soft earth red, known as red bole, armenian bole (after one of its historic sources) or sinopia. The combination of yellow and red bole layers provides a warm orange ground colour. The bole layers are applied in thin, transparent veils, with animal skin glue as the binding agent. The glue is important because when polished with an agate burnisher, it produces a delicate sheen. The inclusion of china clay in the bole also helps to create this burnished, polished effect.

Before the gold leaf is applied to the bole surface, it may be polished with an agate burnisher or gently abraded with very fine wire wool. This gives a very smooth surface upon which the gold can be laid. The gold leaf itself is slightly transparent, so that light can transmit through the leaf to the coloured bole ground below. The general effect is to give a warmth to the gold. Alternatively, cold colours can be used in the bole layers (e.g. green earth), to impart a cool tinge to the gold.

The gold leaf is applied by means of a flat brush made with squirrel hair, known as a gilder's tip. The hair is made slightly greasy, usually by brushing against the human cheek, just enough to lift the fine gold leaf from the gilding cushion. Before application, the gold is transferred from an interleaved book (gold leaf is sold in booklets of 25 leaves, interleaved with non-greasy paper), first by blowing it gently against the edge of a special knife, the gilding knife. This should be made of stainless steel and have one sharp edge and one blunt edge. The knife is usually about 20-25cm long and 2-3cm wide. Care needs to be taken that fingers do not come into contact with the blade of the knife, or greasy residues could be deposited which would quickly attach and ruin the fine, sensitive gold leaves. Against the knife, the gold leaf (about 8cm x 8cm) is gently lifted from the booklet and placed on to a special gilding cushion. This is rectangular in shape, about 12cm x 30cm, consisting of pig skin stretched over a wooden base. This cushion is packed tightly with a fine layer (about 1cm deep) of horsehair, which gives a firm but gentle cushion, against which the gold can be cut with the knife. The gold leaf is cut into small strips, which are then carefully raised from the cushion using the gilder's tip.

To adhere the gold to the bole surface, the gilder gently dampens the bole surface with a little water, using a small, flat or filbert shape soft, hair brush (e.g. ox or sable). The water used for this purpose, the "gilding water", has a small addition of animal skin glue (about 5% liquid glue) and also a drop or two of alcohol, which degreases the surface of the bole as the water is brushed on. This process of dampening the bole with the gilding water partially reactivates the glue in the bole layer, this assures that the gold leaf adheres firmly to it. Strips of gold are laid over the painting surface where required using this technique. It is imperative when gilding to work in a room where there is no draught, so that the precious gold leaf does not fly away. Once the gold is applied to the desired areas and dried thoroughly for a few hours, it can be burnished to a high polish with an agate burnisher. The gold thereby takes on a delicate sheen and gives the impression of solid metal.

In the context of tempera painting, gold leaf is applied on to areas that have been clearly marked out prior to painting. Areas of gold should not be overpainted with tempera, as light will refract differently and contrast with areas where paint has been applied on to gesso. To protect the gold leaf, a fine layer of shellac or sandarac varnish is applied. Alternatively, a varnish made with beeswax, dissolved in cold turpentine could be used, although this will give a matt effect.

Oil Painting

Supports for Oil Painting

Suitable supports for oil painting fall into two categories:

1. Flexible support: cotton canvas, linen canvas, paper.
2. Rigid support: panel, board, or canvas faced on to panel or board.

Flexible Supports

Canvas is a loose term, indicating a painting support usually derived from cotton (e.g. cotton duck canvas), although it may also be used to describe other natural fabrics (flax, linen), or synthetic fabrics such as polyester.

Cotton Duck Canvas

Cotton duck canvas is generally thought to be not as strong and durable as linen canvas, although some heavier weights have proven to be extremely stable. It varies in quality, according to weight and closeness of weave. Generally, a cotton duck canvas with a loose weave and of a light weight (9-10oz) will shrink (tighten) when stretched and sized. The combination of loose weave and light weight produce a fabric that is too easy to pull in opposing directions. When such a canvas is stretched up, the tensions caused by the stretching process may render it unstable as a painting support. When rabbit skin glue has been used for sizing, fluctuations of temperature and humidity may cause the fabric to shrink and expand greatly. Layers of paint applied on to this type of canvas, if at all brittle or underbound, may over time become fragile and show defects such as cracks, or may lose adhesion to the support.

Cotton duck canvases of 12oz and above are available. The heavier weights, especially those with a close weave (no pin-prick holes) and a reasonable texture are recommended. Heavier weights of cotton duck are relatively more expensive but will remain stable and less prone to shrinkage when stretched up. Good quality cotton duck canvas does not have to be pre-shrunk before stretching up, although it can go a little floppy once sized and/or primed. This is especially the case when priming with acrylic, which does not seem to cause the fabric to tighten up very much.

Linen/Flax

Linen, most of which is woven in Belgium or Ireland, has been used for oil painting for many centuries. It is made from fibres of the flax plant and the best grades have great durability, strength and stability. Linen is sometimes referred to as "flax", this may indicate a heavier, coarse weave fabric. The best grades are those that are "wet spun", resulting in a smooth surface. Some "dry spun" linens have a hairy surface.

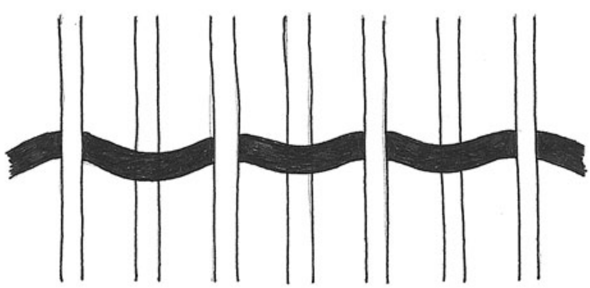


Diagram to Show Warp and Weft Thread

The warp thread runs the length of the canvas. It is pulled tightest during weaving. When stretching up linen, the warp thread should pull across the shortest distance possible, as it is likely to shrink more acutely than the weft thread, when wetted. Ideally, the weft thread forms the length of the stretched fabric. It is likely to shrink less than the warp when wetted.

When linen is removed from the loom, it contracts ("crimps"). Before use for painting, linen can be treated to counteract the crimping effect and straighten the weave of the fabric, by wetting before stretching and sizing. The wetting process is best done by tacking the fabric on to the painting stretcher, quite loosely. The warp should pull across the shortest distance. The fabric is then sprayed with water (use a garden sprayer), or has water painted on to it with a large flat brush. This will also remove any compressed folds. The fabric is left to dry out thoroughly and tightens up as a result.

The degree to which linen will shrink in this process depends upon the nature of the fabric. Lightweight, closely woven fabrics shrink less than heavier fabrics, with a loose weave.

Linen is preferred by many artists because after careful preparation of the ground, the texture of the canvas surface can still be seen and incorporated into the building of the paint layers. Linen is often described as having a "coarse", "medium" or "portrait" (smooth) appearance, this refers to the texture of the canvas surface and the feel of the weight. "Portrait" linen is often preferred by artists working in a detailed manner.

Some fabrics are composed of a mixture of cotton and linen threads: these are prone to unpredictable fluctuations when stretched up, sized and painted upon. Similarly, fabrics composed of linen/polyester mix, or cotton/polyester mix are liable to pull with opposing tensions. The restoration trade has successfully used polyester fabrics for relining paintings. In the future, artists are liable to paint on to polyester flexible supports more and more. Unlike cotton and linen, they are virtually non-moving when paint, primer or size are applied and they retain tension. Their construction is very regular and the rate at which they deteriorate is likely to be less than that of plant-fabrics. Some brands of pre-primed canvas include polyester types.

Pre-Primed Canvas

Linen, cotton duck and polyester painting fabrics come in ready-primed form. Generally supplied by the roll, they are available with a variety of priming preparations and relative quality. The quality of pre-primed canvases needs to be checked prior to purchase. During the priming process, the priming may have been spray-applied, which gives a different finish compared to primer that has been brush-applied by hand. By tradition, canvases were prepared by hand, using lead-oil primer, applied on to glue-sized canvas with long, flat spatulas. In practice, very few companies prepare canvases in this way today. It is far more economical to spray-apply a non-toxic, water-based acrylic priming. It should be borne in mind that the market for pre-primed canvases relates very strongly to the hobby market, where discerning values are less of a concern. For the professional artist looking to work on to a high grade painting ground, the choice of suitable pre-primed canvases is reduced to a handful of specialist companies. The author has found, even in recent years, samples of pre-primed canvases which conform to older traditions, where the canvas fabric has been carefully prepared with a number of special coatings to give painting grounds that are resilient yet gently absorbent, providing a suitable surface on to which oil paint can be applied. Companies offering such canvases often work at a local rather than national or international level, and tend to exist in centres where painting is still a key activity among professional artists. For example, one of the key outlets for artists' materials in Florence still offers linen canvases prepared with special grounds, which approximate to the types of grounds used by artists of previous generations. Similarly, in the south of Germany, a supplier of primed canvases prepares their painting grounds with recipes that approximate to those suggested by Max Doerner. These are acrylic preparations which mimic the gentle absorbency of the older glue-chalk-pigment grounds advocated by Doerner (see Bibliography).

Because pre-primed canvases are supplied in rolls, normally 10 metres in length, perhaps 210cm wide, it is incorrectly assumed by many artists, that such canvas can easily be re-rolled. The opposite may be the case, especially with regard to oil-primed canvas which shows a tendency towards brittleness when rolled or stressed. This is due to the fact that in general, oil-primed canvases are prepared using titanium white as the basic white colourant in the priming. All paint films containing titanium white in oil tend towards brittleness and this is especially the case when the support is rolled or stressed. For example, when stretching such pre-primed canvas, it is very easy to over-pull it and thus cause the priming to crack as it is pulled over the edge of the stretcher using a pair of canvas pliers. Oil-primed canvas may also have a glossy or semi-gloss finish, which can make it difficult for oil paint to adhere to it. For this reason, in recent years, most firms supplying primed canvas have switched to acrylic preparations, which are not only easier for the manufacturer to apply, but also more flexible when stressed. It is possible to apply acrylic primer and achieve a surface that is not too shiny, nor too matt, and which also provides the desired degree of absorption when oil paint is applied.

Pre-primed canvases tend to be more rigid when compared to raw linen or cotton. Because of this, stretching up pre-primed canvas can be more taxing. A pair of canvas pliers is used to hold the painting fabric against the stretcher frame, while tacks or staples are applied to the reverse to fix. It is often necessary to fix tacks or staples to the side edges of the painting when working with pre-primed canvas, in order to gain a tight and even tension across the canvas.

In addition to checking the relative flexibility and gloss of pre-primed canvas it is also advisable to make sure that the fabric has been coated with enough layers of priming to prevent strike-through when oil paint is applied. In the worst case scenario, oil paint, especially when strongly diluted, can sometimes absorb too much into the priming layer and transfer through the priming to the reverse side of the fabric. In such cases, the priming is insufficient and a further coat or two may need to be applied. However, it is better practice not to use such cheaply-made pre-primed canvas. Usually, artists' materials suppliers will have sample swatches of primed canvas which can be checked prior to purchase. The optimum quality of pre-primed canvas will remain flexible when stressed, show durability in use and not allow applied paint to strike-through to the reverse.

Stretching Canvas

Stretcher frames for flexible supports vary greatly in quality and suitability. Mitred stretcher bars are usually made of seasoned pine, or other woods that are reasonably resistant to warping. The wood itself must be free of knots, imperfections and also sap (which will ooze out into the canvas). Imperfections can be isolated by applying "knotting" to the wood. (Knotting varnish is also known as button polish – shellac-based varnish.)

The front edge of the stretcher bars are usually slightly raised, so that the canvas when stretched up does not press directly against the frame or crossbar. Larger paintings will require a crossbar to help stabilise the stretcher frame: for paintings over 36" in any direction it is a good idea to include at least one. Always check that bought stretcher bars are warp-free. Wooden stretchers can warp after purchase. Many artists work in damp, cold studios, where temperature changes can lead to seemingly perfect stretcher bars warping.

The mitred corners of stretcher bars have slot and tenon joints, which fit together. The joints are knocked together with a hammer (preferably a wooden or rubber mallet with a soft head), to form a basic rectangle. Wedges or "keys" can be inserted into the mitred corners to tighten up the fabric, once stretched. This is best done after sizing and priming, where the canvas surface has gone a little limp. "Wedging-out" with the keys will tighten the fabric gently.

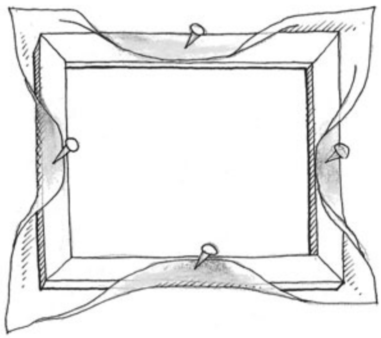
The diagonal measurement of the resultant rectangle is checked to ensure that the frame is square, i.e. the diagonal measurement should be equal. The required amount of canvas is cut and laid on to the floor or table top. It is advisable to lay down a clean sheet (e.g. polythene) to prevent studio floor dirt, or paint residue affecting the fabric. The canvas is cut with enough over-lap (at least 2 inches) around the frame. Canvas is attached to the stretching frame using either a staple gun, or tacks. Staples are easiest to attach: choose a robust staple gun, with strong, non-rusting staples. The canvas threads run parallel with the edge of the frame during stretching. The fabric overlaps the sides and back of the stretcher and is then tacked down, all the way round. The tacks are placed parallel to the top edge of the stretcher frame, about two-thirds of the way from the edge.

Procedure for Stretching Canvas

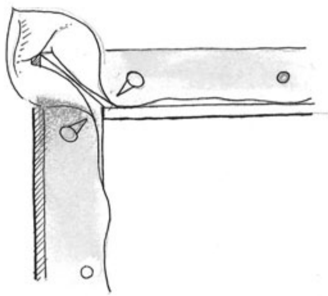
This method aims to reduce the potential stress placed upon the weave of the canvas when wetted with size and/or primer, by evenly distributing the stress throughout the whole canvas area. It also reduces the degree to which the canvas fibres can pull, so that over time, effects of shrinkage or expansion due to humidity/temperature are kept to a minimum. The weave of the canvas is placed parallel to the running edge of the stretcher frame. The warp thread (identified as the length of the canvas, when pulled from the roll) should ideally travel over the shortest distance. For example, on a stretcher frame measuring 20 inches x 40 inches, the warp thread should pull across the 20 inch measurement.

Procedure for Stretching Unprimed Linen

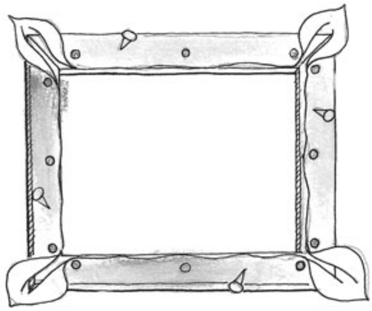
1. Place one tack or staple in the centre of each length.



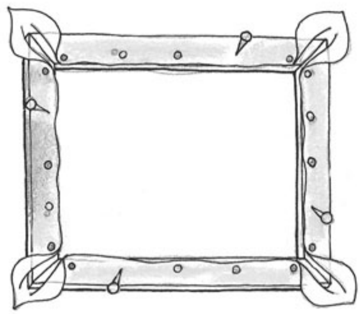
2. The fabric is pulled gently and fastened at each corner. A tack or staple is placed just short of either side of the corner.



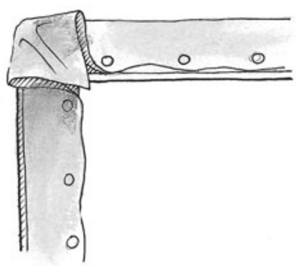
3. The half points are fastened. This can be done by going across one edge, then the opposing edge. This is done on all sides.



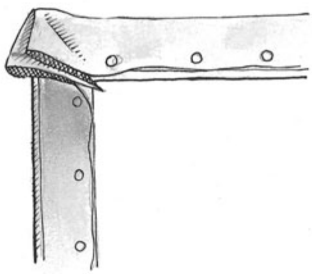
4. The procedure is continued, by fastening the next set of half points. Keep an even distance between each staple/tack. Aim to achieve an even tension over the whole canvas surface.



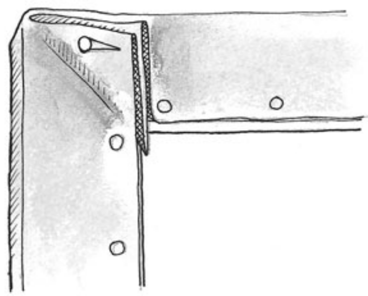
5. Continue fastening the half points.



6. Fold over the corner flaps and fasten.



7. Finally, fasten the corner flaps down.



Paper

Paper as a support for oil painting is not widely recommended. However, heavy watercolour papers (300gsm or preferably even heavier) could be used. The paper should be robust. Choose papers with 100% cotton rag content.

Before painting, the paper is given a coat of rabbit skin glue (1 : 15, left to soak, then a further 15 parts water added before warming through to gain solution). This acts as an isolating layer between the absorbent paper fibres and the actions of oil paint and its solvents. The glue size penetrates the surface of the paper but ideally does not build up a mechanical layer. In the extreme, a thicker layer of glue size may prevent oil paint from bonding successfully with the paper surface. Oil paintings made on paper should be treated with care during storage (as per watercolour paintings), being kept flat at all times. When oil paint is applied on canvas in thin layers, it becomes brittle with age. It follows that when thick oil paint is applied to a thin support such as sized paper, the paint may lose adhesion with the support upon drying out. When painting on paper with oils, it is advised only to paint thinly, in a sketching manner, perhaps for ideas, or try-outs for later paintings on canvas.

The best choice of paper would be a Rough surface watercolour paper of a heavy weight, providing a “key” for oil paint to adhere to, again, prepared with glue size. This procedure provides a support which uses to advantage the texture of the paper. Alternatively, an acrylic ground can be used, which changes the texture of the paper but provides a relatively cheap oil painting support. The best combination may be a layer of acrylic size, to seal the paper surface, followed by an application of a semi-absorbent acrylic gesso. The first coats of oil paint are absorbed slightly into the gesso priming, forming a strong bond between the ground and paint layers. The paper used for such a preparation could be a NOT 300gsm watercolour paper, with just a slight texture. During the preparation process it is necessary to stretch the paper up against a board, using brown gum-strip, to reduce the effects of cockling upon applying the acrylic materials. Once dried, the paper may still show some cockling: simply re-stretch the paper before painting on it.

Commercially Prepared Canvas Paper and Boards

Canvas paper tends to be rather unsatisfactory: it can become very brittle, or be too absorbent. Available brands vary widely. It is probably best to use such materials for sketches only.

Prepared painting boards vary in quality too. They tend to consist of cheap cotton canvas prepared with an acrylic ground and can be overpainted with oil or acrylic paints. The canvas is backed on to a compressed pulp-board/card-board. These backing boards are prone to absorbing moisture, upon which they warp badly. Although certain brands are superior, it is better practice to face rigid supports with canvas as described and use prepared boards for sketches only.

Rigid Supports

Wood

Solid panels made from oak (hard) or poplar (soft) have long been used for painting, although they are rarely employed by artists today. Modern compressed fibre-boards perform quite well by comparison and have the advantage of being available in large sheet format, free of knots and not prone to warping with age, if prepared carefully. Wood absorbs moisture: as it releases moisture it shrinks. This process in turn leads to dimensional instability of the support, resulting in the warping of the surface of the board and subsequent cracking of the applied ground and paint layers. Soft woods, such as poplar, absorb the most moisture - up to 200%. Such panels were employed widely by the Italians during the early Renaissance, being the most readily available source of wood. Oak panels, more commonly used in Northern Europe from the early Renaissance onwards, have more dimensional stability, being cut from harder wood. These types of panels were prepared for painting using a gesso ground, composed of gypsum (Italy) or chalk (Northern Europe) mixed with animal skin glue, to form a tough, hard, yet absorbent ground, ideally suited for egg tempera painting. Developments in painting techniques, to include emulsions of egg tempera with oil and subsequently, the employment of oil alone as a binder for pigments, were matched by modifications to the painting support. Often, underpaintings were made with egg tempera on to an absorbent gesso ground, on which subsequent layers of oil paint could sit without sinking. Alternatively, gesso supports were rendered less absorbent by applying a thin layer of animal skin glue, or an isolating varnish (for example shellac varnish) over the final layer of gesso. To alleviate some of the problems of dimensional stability with wooden panels, strips of cloth (usually linen) were incorporated into the first coat of gesso.

Preparation of Wooden Panel for Oil Painting Using Gesso Ground

Gesso is composed of whiting chalk (calcium carbonate) or gypsum (calcium sulphate), with an animal skin glue, such as rabbit skin glue, or gelatine. There are many different types of chalk available which can be incorporated into gesso grounds. For example, different grades of coarseness of marble dust could be used to obtain a degree of tooth on the painting surface. Such additions are probably best achieved by admixing with a fine chalk such as whiting, gypsum or champagne chalk.

Recipe for Gesso

Prepare a rabbit skin glue solution (1 : 15). Add 15 parts of cold water (by volume) to 1 part of powdered glue. Leave to soak for 30 minutes, until swollen. Warm the glue into a solution in the top pan of a double boiler (or empty food can). This acts as a stock solution for preparing rigid gesso grounds. The strength of animal glues can vary. As a general guide, the glue solution for gesso can be stronger than that normally used for sizing canvas. However, over-strong glue will make the gesso too hard and reduce its absorbency and may cause problems with the dimensional stability of the panel. The first layer of glue solution can be diluted with a further 15 parts of water and requires a small addition of chalk (sprinkle a handful into the solution). This adds a very slight tooth, giving the first coat proper some texture to bond with. Solid wood panels may require a light sanding to make the surface slightly absorbent, so that the glue forms a good bond with the support.

The sealing coat is applied to the face, sides and reverse of the panel, so as to equalise any dimensional tensions caused by the glue. On thin panels, glue applied only to one side may cause the wood to shrink in on itself. When this first sealing coat is dry, the first coat proper is applied. To the warm glue, add slowly, through a sieve (to eradicate lumps) roughly an equal amount by volume of chalk to glue. Wait for all the chalk to disappear under the surface before stirring the mixture. Stirring induces air bubbles to form and needs to be done with patience. The gesso mixture should have a creamy consistency and be free of lumps. This is applied in thin layers with a flat hog varnish brush, or a round "house" style hog sash brush. The hog hair needs to be strong but not too hard, or it will leave behind brush marks. The first coat proper is applied and left to dry for a few moments. When the coat of gesso appears to go dull, a second coat can be applied. If the preceding layer "picks-up", leave to dry a little longer. Five to eight coats can be added to form a tough, thick structure on the panel. The coatings of gesso are applied at right angles to each other to gain a thoroughly bonded ground. The top coat is sanded for a smooth finish.

Thin strips (i.e. off-cuts) of linen can be incorporated into the first layer of gesso. The linen is dipped into the gesso, then placed flat on to the dried "sealing" coat, already applied to the panel. These linen strips are overpainted with layers of gesso which hide their presence. The inclusion of linen strips gives the ground greater dimensional stability.

Oil paint, applied to gesso tends to sink, leaving a very matt paint film. Rather than applying a thin layer of size to reduce absorbency, artists could consider underpainting in egg tempera, followed by subsequent layers of oil, or egg-oil emulsion. The egg tempera underpainting forms a perfect bond with the gesso and provides a matt and slightly absorbent painting surface for oil paint.

Plywood

Thin boards (panels) exert less power when warping than thick panels. Plywood is composed of several thin panels (veneers) glued together, with each sheet glued across the grain of the previous one. Plywood can be rotary cut (to give sheets up to five feet wide), or flat cut, sliced directly from the log. Both types are susceptible to degrees of shrinkage and expansion through swelling. These effects show as fine cracks on the surface of the ply and can permeate through applied ground and paint layers. This problem can be reduced by applying the painting ground over a layer of canvas, glued to the board. Three-ply birch or poplar sheets are recommended. Sizes over two feet in any direction can be reinforced to offset warping by fastening battening to the reverse. Ply is less prone to destruction by wood boring insects than wooden panels of oak and poplar.

Facing Ply with Canvas

Stick a piece of canvas down on to the face and sides, with flaps glued over on to the reverse. Use cotton canvas with an open weave, which prevents the glue from being trapped under the fabric surface. Apply a solution of rabbit skin glue (1 : 15) to the face, sides and reverse (the whole of the back) of the ply and stick the fabric down, smoothing out any trapped pockets of air. A layer of size (diluted a further 15 parts with water) should be coated over the fabric once dry, to isolate it from the priming layer. Over this facing of fabric, two types of ground can be applied:

- Gesso ground, as described for solid panels
- Oil Ground. This could be lead primer, or a reliable brand of alkyd primer.

Acrylic Priming for Plywood or Blockboard

Alternatively, plyboard can be prepared with acrylic primer, using the following procedure. The board is faced with lightweight cotton canvas, or linen. The overlaps are tacked to the reverse with staples. Acrylic primer can be painted straight over the fabric (does not need to be sealed as is the case with oil priming).

Reinforcing Rigid Supports

Strong adhesives based an acrylic polymers can be used for fixing batons to the reverse of rigid supports. The glue is applied as thinly as possible. Wood glues, for example a PVA Scotch glue, or casein based glues could also be used. It is important that the glue does not come into contact with the painting surface or ground. Avoid using screws or nails, which may rust or cause splits in the wood surface. Animal glues should also be avoided due to their tendency to fluctuate according to humidity, and become brittle with age.

While the glue is drying the frame is clamped tight: batons of wood are interleaved between metal clamp and board, to protect the surface. The glue is left to dry for at least 24 hours. The supporting frame is made from seasoned wood (i.e. thoroughly dried out) of a similar thickness and nature to standard stretching frames. The frame can take the form of simple batons, stuck down to the reverse, or a stronger jointed structure.

Masonite (also known as Hardboard)

Hardboard is made by exploding wood fibre with steam, compressed into sheets under great pressure. It is available in two basic forms, tempered and untempered. The untempered variety is best, as tempered hardboard is treated with paraffin oil, which leaves a greasy residue. This can resist priming or sizing applications if not carefully degreased with methylated spirits (alcohol). The reverse side of hardboard has a rough "wove" appearance, which can also be used for painting. However, this face of the board has a more fibrous nature and should be prepared for painting using a primer that contains the least amount of moisture. Neat acrylic primer is probably best.

Sanding the smooth side of untempered hardboard to give a slight tooth, before application of sizing/priming, disturbs the fibres on the surface of the ground. Moisture allowed to absorb into the board can cause the fibres to expand, affecting its dimensional stability. The smooth surface should be degreased prior to application of sizing/priming. This is done with methylated spirits (alcohol), applied with a clean cotton rag on to the surface and left to dry thoroughly. Hardboard is prone to deteriorate if too much moisture penetrates the surface (for example, dilute acrylic primer). It may also warp if stored in a damp area. It is often recommended that alkyd based primers be applied neat to hardboard but these can leave a very shiny, slippery surface if undiluted. Acrylic primer can be applied neat to degreased hardboard. Without degreasing, the acrylic primer may not adhere to the surface.

Hardboard is prone to warping in larger sizes. A supporting frame can be attached to alleviate this problem. Hardboard can also be faced with canvas, as described for ply and blockboard. Many artists like to face hardboard with muslin, a light cotton fabric with a very loose weave. This gives an interesting texture, is inexpensive and is highly suited to making “on the spot” sketches, where paint is required to be fluid, yet needs to catch the painting surface lightly.

Medium Density Fibreboard (MDF)

Another type of exploded fibreboard. The wood fibres are compressed to form a compact, homogenous surface. MDF forms a highly stable painting support, which is warp resistant (choose a thickness over 12mm). It can be prepared with traditional gesso, animal size and oil primer, or acrylic grounds. MDF is also quite moisture resistant, although the edges tend to be more absorbent. It does not crack as do natural woods, ply and blockboard.

MDF can be difficult to obtain, cut to preferred sizes, due to the inclusion in its manufacture of urea-formaldehyde resins, which are thought to be carcinogenic in nature. This is not such a problem to the artist using a cut piece of board but rather to the timber merchant, whose cutting machinery releases the wood fibres into the working environment. However, a new specification of MDF, “Zero Formaldehyde” (ZF) is available, using a polyurethane resin in place of urea-formaldehyde. Canvas can be faced to MDF, to provide a cheap and rigid alternative to buying stretcher pieces. A piece of canvas is cut with 2-3 inch overlaps and the MDF sheet laid down on to the canvas. The canvas is then tacked to the reverse of the board. An archival, acrylic adhesive can be applied to the reverse of the board to assist the process of stretching and tacking. The canvas is tacked down with staples while the glue is drying but these are applied only to the reverse, not the sides. When the canvas has been pulled tight all the way round, the face of the canvas is coated with one or two layers of neat acrylic primer.

Honeycomb Aluminium Panel

Lighter than similar sized boards, aluminium panel with a honeycomb centre is warp resistant and can be prepared successfully as a support for oil painting. The face of the panel is first degreased, then lightly abraded to give a slight key. Acrylic primer can be applied directly to the panel and subsequently sanded to give a smoother finish. This type of rigid support may be preferred when using brands of paint with less flexibility than artists' oil colours. For example, household oil-based paints often contain less flexible oil components, additions of varnish, chalk and drier which can leave the paint film brittle. Painting on to a well-prepared rigid ground with such materials will reduce the degree to which the paint flakes and embrittles, although the surface is temperature sensitive and rather easily dented.

Sizing and Priming Supports for Oil Painting

Some sources of raw canvas are sold as being pH neutral, affording some resistance to ageing. Recent research into the ageing properties of painting fabrics[1] suggests that the life of a canvas can be extended by pretreating with a de-acidification agent.

Rabbit Skin Glue

Rabbit skin glue or gelatine can be used to size canvas, prior to applying a coat of oil or alkyd primer. The glue impregnates the

1. Stephen Hackney and Torben Ernst, "The Applicability of Alkaline Reserves to Painting Canvases." *Measured Opinions*, UKIC.

canvas weave, forming a barrier between the fabric and the layer of primer. Sizing prevents the ground (priming) layers of paint from seeping through to the back of the canvas. Rabbit skin glue, like other animal skin glues, is a hygroscopic material: it reacts to extremes of moisture and humidity by swelling and contracting. When this occurs, brittle priming layers applied over canvas sized with skin glue may be prone to crack or blister. It is therefore advisable to choose a primer that is flexible, such as lead white primer. However, acrylic primings are more flexible and easier to use and may be more appropriate in the long term. Rabbit skin glue should be applied to canvas in one thin layer, while it is still warm but never hot. Do not try to re-use animal glue once made up: although it will keep for a few days in the fridge, it will not have the same adhesive strength when re-warmed.

Recipe for Rabbit Skin Glue for Sizing (1 : 30), for Canvas (Flexible Support)

Rabbit skin glue grains	1 part (by volume, i.e. 1 x tablespoon)
Cold water	15 parts

Add the water to the glue in a suitable container. A double boiler is best but an empty food tin (washed thoroughly) can be used. A double boiler comprises two pans, the lower one filled with water is in direct contact with the heat source. The upper pan sits inside the lower pan, allowing animal glues to be warmed through without being scorched. If a double boiler is unattainable, use an old pan, into which an empty food can is placed. Leave the glue to soak for half an hour, during which time it swells up to form a sloppy paste. Add a further 15 parts water to the mixture. To form a solution, the glue has to be warmed through in a double boiler.

Place the glue in the upper pan of a double boiler. The lower pan is half-filled with water. The glue has to be warmed through gently, if it is allowed to boil it will lose some adhesive strength. The warmed solution should be free of lumps. When left to cool, the set jelly should ideally break with a ragged fracture when pressed with a finger.

Animal skin glues can be hardened by the addition of alum (aluminium potassium sulphate), to reduce the extent to which they are resoluble. However, this makes the sizing very brittle and the alum can attack the canvas fabric. Powdered alum (available from pharmacies and some art suppliers) is soaked overnight and warmed through, if necessary, to form a clear solution. Use one part by volume of alum to ten parts of glue. The alum is soaked in the water to be used for making the glue solution. Rabbit skin glue is sold in powder form, in small, flaked grains and in the form of sheets (sheets should be left to swell overnight).

Rabbit skin glue is a natural product, prone to fluctuations in quality and therefore different batches of glue may have a variety of strengths. Good animal skin glue appears pale as a powder and has only a pale straw-yellow colour when made into a clear solution. Darker glues should be avoided, as they may be more brittle and may darken even more when warmed through. The glue size is applied to the face of the stretched fabric. Care should be taken to apply it to the edges, flaps and especially the corner overlaps of the canvas. Subsequent layers of primer should also follow this rule. The glue size is applied while just warm. The action of sizing the fabric will make it become taut as the water in the glue solution causes the fabric to tighten up. If the glue is too strong, the canvas will become as tight as a drum. While this might seem to be an advantage, giving a strong support, strong glue size, being very hygroscopic is more prone to fluctuations later from the effects of humidity.

Some authorities advise glue size to be applied cold, with a spatula, although this does not penetrate to the fibres of the yarn and can form a brittle skin, prone to cracking.

Gelatine

Gelatine is derived from collagen, which is found in animal bones and skin. It is carefully refined to form a pure, virtually colourless glue, usually sold in the form of thin sheets. The high standards demanded by the food industry mean that gelatine is usually very pure and not as affected by fluctuations in quality as can be the case with rabbit skin glue. Industrial grades have a slight yellow colour, due to the sheets' thickness. Gelatine is left to dissolve until a clear solution forms. It dissolves quickly in cold water, swelling appreciably but does not have to be left as long as rabbit skin glue. According to Wehlte[2], “gelatine has good adhesive properties, the jelly is relatively firm, and the warm solution has a high viscosity”.

As a guide, around one part gelatine (by volume, roughly one-eighth of a sheet) is immersed in 40-50 parts water. When the solution is clear, as with rabbit skin, the glue is warmed through and brushed on to the canvas, in one or two thin applications. When used in recipes for gesso on to rigid supports, the strength of the gelatine glue could be higher.

Brushes for Applying Size to Canvas

Hog varnishing brushes can be used for sizing canvas. Flat brushes, with short handles, of a good width (3-4 inches) and with a length out of $1\frac{1}{2}$ inches hold a good amount of liquid, enabling size to cover large areas of unprimed canvas rapidly. Thicker household type brushes can be used, but be careful when selecting them that the hair does not come loose from the ferrule. Flat hog hair brushes with a shorter hair length out from the ferrule ($\frac{1}{2}$ – $\frac{3}{4}$ inches), for example, a “straight mottler” can be used to good effect for applying cold size, where the glue needs to be pushed out across the canvas and also into its pores.

Flat hog varnish brushes can also be used for applying primer, those with slightly stiff hair work well, enabling the primer to be applied in thin layers, stroked into the canvas weave.

Priming

Sizing is applied to reduce the absorbency of the fabric so that subsequent applications of primer and paint are less prone to sinking. The priming layer is required to fill the pores of the canvas weave to provide a stable and integrated bonding surface for oil paint.

If the sizing has been applied too thickly, the primer cannot properly combine with the weave of the fabric. Because of this, it is

2. Kurt Wehlte, *The Materials and Techniques of Painting (Werkstoffe und Techiken der Malerei),* Otto Maier Verlag, 1967

advisable to apply not more than two, thin and even coats of size to the fabric. The priming coat is applied to form a tough, durable ground on which to work. Primer alters the absorbency of the fabric, its texture, colour and stiffness.

Some artists choose to sand in between coats of primer, to achieve a smoother, flat surface, which shows the canvas weave.

Lead White Primer

Lead-based pigments in artists' paints can constitute a considerable danger to health if used improperly. Their use in industry is increasingly limited due to their toxicity. Lead white can be extremely toxic and should not be handled without thorough precautions. Artists should be aware of the associated dangers before considering using these pigment types. Lead white primer has been widely used as a suitable primer for oil painting on stretched canvas, over a dried application of glue size. It is the most flexible of white pigments in oil and dries thoroughly to form a durable paint film.

Primers made with zinc or titanium white, or mixtures of zinc and titanium in oil, can be more brittle. In respect to this, avoid household primers and undercoats. These are designed to endure for only a limited time scale and may contain unknown additions of drier, varnish, etc.

Lead white primer is sold in cans, usually as a thick paste, which is thinned down slightly with turpentine or white spirit, so that it can be brushed out easily. Alternatively the neat primer can be spread out on to the sized canvas using a metal spatula. Lead white primer can also be prepared from the dry pigment with linseed oil on a glass slab, mixed to a stiff paste and then thinned with turpentine so that it can be brushed out evenly.

Lead white pigment is toxic. Great care should be taken when using the dry powder. Wear protective gloves and a high quality particle filter mask, and further protect skin from contact with the pigment by applying a barrier cream. Wash hands thoroughly after use. Never eat, smoke or drink when in contact with this, or other dry pigments.

Recipe for lead white oil primer

Cremnitz white pigment (basic lead carbonate, lead white)	1kg
Refined linseed oil	approx. 250ml

Wet the pigment with enough oil to form a stiff paste on a glass or marble slab. A palette knife can be used to mix the pigment and oil together. Store the mass of the mixture to one side of the palette, then gradually mull small portions of it, moving the glass muller in a figure of eight motion. Mull the whole batch of primer, then leave to rest on absorbent paper for an hour or so. Repeat the process, so that the final primer mixture is smoothly mulled. The resultant stiff paste can be applied neat with a spatula, or thinned down a little with rectified turpentine. Lead white primer is applied to canvas that has been prepared with glue size as described. The primer should be applied in thin coats to the edges, overlaps and corner flaps for maximum protection of the fabric. Two thin coats will suffice; leave the first coat to dry for a week before applying the second. After the second coat, the primed canvas should be left to cure thoroughly, for 4-6 months before being painted on. This long drying time is required because oil paint applied to the priming ground during the curing process would be absorbed into the primer. Curing draws oil from applied paint layers, leaving it underbound and making it too dry to adhere to the support sufficiently.

Once the priming coat is thoroughly cured, lead white primer provides an ideal ground for oil painting: it is lean (low oil content) and slightly absorbent.

The linseed oil in which lead white is ground turns the priming coat yellow if stored away from light (i.e. in a cupboard). The white colour is restored upon exposure to sunlight, although it remains yellow behind the visible surface coat.

Comparison of Primings for Oil Paintings

Titanium white, when carefully prepared in an alkyd resin is fast drying and thought to stay flexible, while acrylic primings are by comparison very flexible, fast drying and not prone to yellowing. Both alkyd and acrylic primings are non-toxic.

The use of casein gesso, animal glue gesso and half oil and egg-oil grounds provide relatively brittle primings when applied to stretched canvas. However, in historical terms, such grounds have been important and some artists continue to use them today.

One common complaint with modern acrylic primings, is that the colour of the ground (derived from titanium white, with calcium carbonate in an acrylic polymer emulsion) is too bright a white. With older painting grounds, for example lead white ground in oil, the colour is more subtle and slightly warmish. Similarly, painting grounds based on water-dilutable mixtures tend to give a more subtle colour to the ground.

Chalk Grounds for Oil Painting

Early oil paintings would have been primed with similar materials to those used on wooden panels, namely gesso, composed from an animal glue mixed with chalk. Such mixtures tend towards brittleness when applied to flexible supports like canvas. However, if only one or two coats of this gesso are applied, with the priming being worked into the weave of the canvas fabric so that there is no significant build-up of priming, a workable ground may be achieved. By contrast to the glue formula for rigid panels, the glue strength needs to be somewhat dilute, perhaps one part rabbit glue to 30 parts water. After being left to soak for 30 minutes to one hour, the swollen glue-paste is gently warmed through to a solution and applied while just warm. The temperature of the glue becomes more important when applying to canvas. If the glue is hot, or boiling, it will introduce more tension across the painting fabric. Subsequent changes in humidity will affect the glue and cause the fabric either to tighten or relax. When the glue is applied just warm enough so that it can be brushed out (i.e. not re-forming into a jelly), much less tension is present in the glue film. Prior to the application of the gesso, the canvas is treated with two coats of glue size (again, at 1 : 30 glue strength). Rabbit glue size is commonly used today, but prior to the 19th century, hide glues from cattle would have been used, or goatskin glue, derived from parchment clippings. In practical terms it is probably best to use rabbit glue, as this provides a good degree of flexibility and, where high grades of glue have been chosen, it is pale in colour and free from impurities.

The canvas is attached to the stretcher frame before the glue size is applied. Each coat of glue size is left to dry. Between coats, it may be useful to abrade the surface lightly with a pumice stone, to remove or reduce any knots or anomalies in the structure of the painting fabric. It is also advisable to "wash" linen fabric before stretching. This process removes any residual starch in the cloth, and reduces the degree to which it will shrink when sizing is applied. Once the first two coats of glue size have been applied, the canvas is dry and the surface smooth, subsequent coatings of gesso can be added. Best practice is to apply as few coats as possible, with each priming being worked into the canvas surface with a soft hog varnish brush. This procedure allows the structure of the canvas weave to remain visible and also produces a relatively thin, even application of priming. To the stock glue solution, an equal volume of chalk* is added, which is left to soak into the glue and drop to the bottom of the mixture, prior to stirring. This helps to alleviate air-bubbles.

If the gesso mixture returns to a jelly, simply stand it in a bath of hot water (from a recently boiled kettle) and use when brushable. White pigment can be added to the gesso. Historically, this would be lead white, but other whites such as zinc white, titanium white or permanent white (blanc fix) could also be used. The addition of white pigment produces a brighter white ground, but may alter the relative absorbency of the priming.

Many artists experimented with gesso primings, in the hope that they could be made more flexible by the inclusion of plasticising agents. These would have included honey, starch glues, soap and oil. All these additives create some degree of flexibility but tend to cause problems over time. For example, the addition of soap leaves the painting ground too greasy for applications of oil colour to adhere properly. Honey remains hygroscopic (water-reactive), while the addition of oil to gesso tends to give a painting ground that possesses uneven absorption. Perhaps the most successful of these

* The type of chalk used is a personal decision. Historically, gypsum (calcium sulphate) was used in Southern Europe, while whiting or champagne chalk (calcium carbonate) was used in Northern Europe.

additives is wheat starch glue, which is thought to have been used during the golden period of Venetian painting in the 1600s. The wheat starch glue provides a degree of flexibility without unduly altering the absorbency of the gesso ground.

Gesso can be rendered more flexible by the addition of linseed oil, drop by drop into the warm chalk-glue mixture. A small addition of oil, perhaps 15-20% provides enough flexibility to give a priming that will move with the painting fabric and renders the gesso mixture dilutable with water (it forms a kind of emulsion). Such grounds are often referred to as half-oil, or half-chalk grounds. The addition of the oil is a difficult process: it must be added slowly, drop by drop, in the manner of making mayonnaise, until it forms a suspension within the warm gesso. The author has found that if the gesso mixture is left to cool so that it forms a jelly, the oil can then be worked into this on a sheet of glass using a spatula. When warmed through, the resulting solution tends to stay in suspension. The addition of linseed oil makes the resulting ground thicker and it will take longer to dry. If one uses refined linseed oil, a thin coat of the ground will dry in perhaps 2-3 days. It is important when applying such a ground that the priming is worked into the canvas structure (i.e. it is a smooth, even, thin film). This half-oil ground needs to be applied on top of 1-2 coats of glue size.

For small scale paintings (perhaps up to 50cm x 50cm), a special smooth ground can be made using a mixture of gesso (glue size + chalk) which is mixed with an equal volume of egg. The whole egg is added into the warm gesso and they are mixed together thoroughly. The resultant ground is somewhat shiny in appearance at first, but upon drying leaves a satin sheen. This ground needs to be applied over 1-2 coats of glue size. It works best on to fine/portrait linen, where thin applications of the ground help provide a flat, even working surface, which allows the structure of the linen fabric to be seen. Only one coat should be applied to guarantee a consistent finish.

Larger size paintings are more difficult with this egg-gesso ground, as it is more difficult to achieve evenness over a larger surface. Also, the ground is relatively brittle upon drying and becomes increasingly more so over time, thereby being more affected by flexing of the canvas.

Alkyd Primer

A fast drying primer based on an oil-modified alkyd resin. The advantage of using such a primer is that it has low toxicity and dries quickly. Each coat can be overpainted after 24 hours. Alkyd primer is applied to canvas that has been prepared with a coat of glue size. It can also be applied directly (without pre-sizing with glue size) to wood and hardboard, for overpainting with oil colours. This primer can be diluted in strength as required with white spirit/turpentine. Alkyd primings can dry to give a glossy coating, which may be too slippery for oil painting, although the degree of gloss can be manipulated by thinning the primer.

Acrylic Primer

Primers based on acrylic polymer resin thinned with water, are flexible, durable and dry to become water-insoluble. They are also non-hazardous to use. Such primers can be applied directly to stretched raw canvas and dry thoroughly in only a few hours (preferably leave to dry overnight). They are variously described as acrylic, universal or acrylic gesso primer. The term "gesso" is misleading, as such primings may not have the same absorbency as traditional gesso grounds prepared with animal glue and chalk. The absorbency of commercially available acrylic primers will vary from brand to brand.

Ideally, an acrylic primer should have some absorbency and not be too shiny on the surface as this would be too slippery for oil colour to adhere to properly. The primer should allow the weave of the canvas to be apparent and enable oil colour to become absorbed into the surface texture slightly, to achieve a good bonding. Acrylic primers can be thinned down with water, although, when very heavily diluted, acrylic primer may become too absorbent. On to linens, acrylic primers applied to the raw fabric tend to penetrate through to the back. To counter this, acrylic size or water-thinned acrylic matt medium can be applied, to impregnate the surface and prevent sinking of the priming coat. Acrylic size is a milky white soft paste which dries clear. The soft formulation of acrylic size does not interfere with the texture of the canvas weave, or clog up the pores of the fabric. Other acrylic mediums could be used: for example, a flowing matt acrylic medium, diluted 30% with water to avoid applying a coating that is too thick. Gloss mediums tend to build up too much of a surface and have little or no absorbency. PVA is best avoided: it is prone to yellowing and embrittlement with age. Animal glue sizing underneath acrylic primings is not recommended, as the glue becomes increasingly hard and brittle with age, while the acrylic remains durable and flexible.

Acrylic primer can be applied neat to wooden panels and hardboard. However, the water content tends to swell wood fibres. Prime the edges first to reduce the risk of swelling and apply without water-dilution if possible. Such surfaces should always be dirt and grease-free, to aid adhesion. Methylated spirits (alcohol) can be used to degrease the surface: this is always recommended, as wooden boards are invariably handled when being cut and sold.

Properties of Oil Paints

Oil paint is made by combining a drying vegetable oil such as linseed oil with high quality pigments, to form a cohesive paint paste. During the manufacturing process, certain additive materials may be included to enhance the brushing quality (rheology) of the paint, alter the consistency and control the drying time.

The manufacturing process for oil paint can differ from one brand of paint to another. It would be true to say that there is no accepted standard for making artists' oil paints. By contrast, each manufacturer (rather like individual artists) has their own philosophy as regards what would constitute the optimum oil colour. As a consequence, there are a great many differences between paint brands. Some are stiff in consistency, some are very glossy, others matt, and so on. There is no "best" oil paint, as such, to recommend; each individual artist will adopt an oil paint that suits the context of their own work. This is an important facet to understand about oil paint: if one goes through life using the same brand, from school, through art school and into professional practice, one may end up not making the most of one's potential. The best advice as regards choosing oil paints is to try more than one brand, and to compare and contrast between brands before settling on one particular make. In practice, many artists work with a variety of brands within the same palette.

Manufactured oil colours are sold from colour charts, which may identify aspects such as the mass tone, undertone, transparency, opacity and permanence of each colour. Some also show how each colour admixes with white. There is no industry standard for the production of these colour charts, so they tend to vary according to the manufacturer. If possible, refer to a hand-painted colour chart as printed charts are always made within the bounds of commercial colour printing, so that the colours shown are a guide only. The best way to judge an oil colour is to buy a few tubes and try them against what you already have. In particular, some attention should be paid to whites. Often, cheaper, or poorly made oil colour whites can show a great deal of yellowing (darkening) after a relatively short period of time. Also, by admixing a colour (e.g. ultramarine blue) with a white, some indication of its relative strength can be ascertained and compared to the same colour in another brand. Tinting strength alone may not be such an important aspect: look also at how the paint brushes out, its consistency, glossiness, drying time, etc.

A number of terms are often applied in the context of artists' oil paints, which require some explanation.

Oil to Pigment Ratio

Each pigment requires a different recipe in order to make a balanced oil paint paste. In order to keep oil paint stable in a metal tube, certain additives are required, which can in turn alter the working characteristics of the paint, when compared to an oil paint made simply by hand, combining only pigment with oil. One governing factor in the manufacture of stable, balanced tube oil colours, is the ratio of oil required to the quantity of pigment and other dry materials. If too much oil is included in the mixture, the paint may be sloppy, or over time, the excess oil may leak out of the mixture. This usually becomes apparent when the cap of the oil paint tube is bursting with oil, or where oil has leached from the base of the tube.

Each pigment absorbs oil in a different way from the next. If the particle size is large and irregular (as is the case with green earth), it will require a larger proportion of oil than a pigment with a small particle size and a regular form. Consequently, manufacturers have to adopt a different recipe for each colour. This partly explains the high cost of artists' oil colours: not only are the raw material costs a factor, but the processing time and "aftercare" is also an issue. Most manufacturers will keep a record of each batch of paint, for cross reference. Also, when testing each paint batch, the manufacturer may compare the paint to batches from previous makings. In this way, small changes can be made to retain consistency from year to year.

Drying Time

According to the philosophy of each manufacturer, an optimum drying time for a paint range may be agreed upon. In some cases, this means adding no drying agent at all: allowing the paint to dry naturally. In other cases, all colours may have a drying agent added, so that they all dry within a specific time window. In the case of refined linseed oil for example, a thin coating of this will dry in about 2-3 days when mixed with pigment. However, some pigments, such as raw umber and lead white, have a catalytic effect on the oil, causing the paint film to dry out (cure) at a faster rate (perhaps 1-2 days). By contrast, other pigments have a retarding effect on the oil in which they are ground. Alizarin crimson and genuine vermilion will take a prolonged period to dry out thoroughly. From an artist's point of view, the best kind of paint is probably that which takes a little longer to dry out, affording them more time to rework passages of paint. This is a dilemma in present times, as the mass market for artists' materials has moved progressively towards supplying the amateur artist and hobbyist. For that market, a quick drying time is preferred. By contrast, the professional artist may be more discerning when considering the drying time of oil colours. A longer drying period may be preferred. The table of drying times for pigments hand-ground in linseed oil, shown on pages 301-304 is a good reference point and will give an indication of the drying times for specific pigments. However, this does not allow for the inclusions of drying agent that a manufacturer may adopt within a paint range. In short, there is no way to gauge the drying time of a manufactured paint other than by using it and noting how long it takes to dry. Another factor to consider with the drying time of colours, relates to the atmospheric conditions present when the painting is made. For example, a painting made in winter, in England during a damp, cold spell, will dry far slower than a painting made during a warm period in late spring. Also, paintings made in an ambient temperature (e.g. a modern house that is centrally heated) may dry a lot quicker than a painting made in a cold, draughty and possibly damp studio space. All these factors need to be considered.

In the manufacturing process, a number of drying agents are used. The principal choice for most manufacturers is cobalt siccative, also known as cobalt drier. This is based on cobalt (metal) salts in a liquid form and a small amount is added to the paint mixture during the mixing process. With cobalt siccative, the paint film dries first on the surface, then slowly through to the core. When paints containing cobalt siccative are packaged into tins, they tend to skin over on the surface very quickly. While the paint underneath the surface remains serviceable, a quantity of paint will become unusable, having formed a substantial skin. The same process can take place on the painting, where paint is applied thickly: the core of the paint may stay wet and squidgy, while the surface is dried to a hard skin. Other drying agents such as manganese and lead driers may also be found, but due to their relative toxicity are less and less common in manufactured paints.

Some manufacturers publicise the fact that they do not add drying agents. Such paints are worth examining, especially if working in a dry, warm environment.

Consistency

Tube oil colour is often a thick, buttery paste, which squeezes readily from the tube and is subsequently easy to dilute or admix with solvent and/or paint medium. However, there is no standard consistency for oil colours, it can differ from brand to brand and even within one brand, according to the character of the pigment used. If a paint range exhibits differences in consistency between one colour and another, this is not necessarily a disadvantage, it may be intended. A plus point for many artists when working with oil colours can be when a colour conforms to the characteristic of the pigment used. For example, cerulean blue is a metal-based pigment, with a slightly grainy character. When brushed out to a thin film, the particle size tends to show with a mattish finish, which can be attractive from an aesthetic point of view. If a paint is made to embellish and heighten this facet, it can be said to conform to the characteristic of the pigment used. By contrast, some brands of oil colour exhibit the same consistency and film finish, regardless of the pigment used. In such circumstances, the manufacturer has opted for a uniform, homogenised finish to all the colours across the range. This may be of interest to the system painter or to someone who paints as a hobby and wants all the colours to behave the same. However, it may be a source of frustration to the serious artist who values the exact differences of nuance between one pigment and another.

The consistency of the paint is governed to some extent by the manufacturing process and the inclusion of various additives. For example, the milling process of some brands of oil colour involves the formation of a gel consistency, achieved by putting linseed oil with aluminium stearate, a type of metal soap. This "gel" consistency affords a similar, "uniform" consistency to each colour and perhaps cuts down on processing time. However, the traditional way to make oil paint is to afford each colour a separate recipe, which will also involve different amounts of additive material, according to the nature of the pigment or pigments used to make the colour.

The inclusion of small amounts of additives can help provide stabilised paint pastes with optimum light refractive qualities. An overuse of additives may lead to a cheapening or deadening of the colour value and may also ruin the stability of consistency. For example, aluminium hydrate is often included in oil paints to give a firm, buttery consistency. Because this filler/additive is a low tinting strength white, with great transparency, it is often used with pigments of a transparent nature. However, when overused, the consistency turns to a mushy paste rather like margarine, and the colour also loses its brilliance, giving a frosty/matt finish to the dried paint film. A precise and calculated inclusion of an additive/filler material can improve a paint, but this may be costly and again, is reflected in the high price of good quality artists' oil colours.

The choice by manufacturers of a stiffish, buttery paint paste relates more to the fact that it is packaged into metal tubes, than to the consistency desired by the artist. It is true that an artist like Van Gogh found the possibility of squeezing colour direct from the tube on to the painting surface attractive. However, many artists prefer to put colour out on to a palette, or into some kind of vessel, and then admix the paint with solvent or a paint medium to alter the consistency of the oil colour. There is therefore a strong argument for the supply of oil colour in a more liquid form. Sadly, because this type of oil colour would dry out on the surface and skin over, such paints remain at the idea stage, although artists hand-making their own oil colours can certainly achieve this kind of consistency, as long as they make the paint and use it directly.

In modern times we have become very accustomed to the notion that we paint with ready-made paints and paint mediums. How different the situation would have been for artists working prior to the invention of the collapsible metal tube in the 1840s, when oil colours had to be hand-ground (perhaps by an apprentice if one was lucky) and used within a day or so. Some artists were able to keep oil paints for a few weeks or months, stored in a tied-up pig's bladder, but by and large this was a woefully impractical system. For most artists, the preparation of colours on to the palette was an important part of the painting process itself. As a consequence, it can be argued that it is good practice for all artists to learn how to hand-make oil colours, as this is perhaps the best way to learn the working properties of individual pigments.

Rheology

The brushing quality of a paint is referred to in terms of its rheology. Some paints are prepared so that they brush out smoothly once squeezed from the tube. Others may be in the form of a very stiff paste, which the artist has to manipulate further with solvent or paint medium. Paints based on refined linseed oil tend to show brush marks, whereas those based on cold-pressed linseed oil tend to hide them, because the paint itself has a self-levelling character. When choosing oil colours, these factors may become important: if one does not want to see directional brushmarks or brushstrokes, then choose a paint based on cold-pressed linseed oil. Alternatively, any oil paint can be manipulated by admixing with a small amount of a paint medium such as stand oil, which imparts a self-levelling characteristic into the paint film. Some paints are manufactured as basic "paint pastes" and actually work better when admixed with a specific paint medium. With each brand of paint it makes sense not only to look at the colour chart in terms of the actual colour, but also to look for information from the manufacturer relating to the best working methods. Some manufacturers publish small handbooks which explain how to get the best results from a paint.

Mass Tone and Undertone

The mass tone can be said to relate to the paint when painted without dilution (neat). The undertone relates to when a paint is diluted or brushed out strongly, to reveal any transparency. With some pigments, the mass tone and undertone can indicate a difference of colour. For example, nickel azo yellow has a mustard tinge when applied neat as a mass tone but becomes a warmer yellow when brushed out to a glaze.

Binding Media for Oil Paint

Oil paints are based on combinations of pigment(s) into drying vegetable oils such as linseed oil. It is best to understand the properties of these oils before beginning to work with oil colours, or when hand-making oil colours. Oil paints dry through a complex process of oxidisation, whereby the paint film gradually hardens to form, in the case of linseed oil, a leathery, durable film. During this process, oxygen is attracted to the open, wet fresh oil paint surface but paradoxically, expelled from the mixture at the same time. This continues for a prolonged period, until finally more oxygen is coming out than going in. Typically, the surface of the paint film dries first, partially trapping oxygen underneath. This trapped oxygen slowly leaks out until the paint film hardens in the core. As a consequence, it can be seen that paint films that are thin, dry much quicker than fat paint films.

(N.B. Because some pigments seem to retard the drying/oxidisation process, it is not possible to use them to paint thickly if one expects the paint film to dry successfully. As a guide, for thicker passages of oil paint, it is wise to use opaque colours with a regular particle shape such as the cadmium yellows and reds, or the synthetic iron oxides. Another factor to consider with thicker passages of oil paint, is that when the paint takes a long time to dry, it is more than likely that the sheen of the paint will become slightly matt. This can be countered somewhat by admixing a small amount of paint medium – e.g. stand oil/dammar varnish – to help retain an even gloss.)

Different oils give different paint film sheens. Where linseed oil tends to form a hard, leathery skin, poppy oil, which dries slowly, gives a matt, slightly frosted sheen. Choice of the appropriate oil when hand-making oil colours can be crucial to the paint film appearance.

Refined Linseed Oil

The most commonly used oil for modern artists' colours is refined, or heat-expressed linseed oil. As the name suggests, the seeds of the flax plant are pressed using a heat process, through metal rollers. The resultant oil is a dark orange-brown colour but is bleached to provide a pale straw colour. Over time, this pale colour reverts to its original darker shade, thereby introducing a warm brownish tinge to all the colours with which it has been ground to make paint. While this defect is alarming to many artists, the very patina of age that oil paints exhibit is of great value to the auction house. If an oil painting has the characteristic warm glow of aged linseed oil, then it does indeed look old. It can be argued that the responsibility of the artist is to the image, not to the final care, storage and exhibition of the artwork. However, many artists are concerned that the images they paint should remain in a similar condition once the painting leaves the studio. Refined linseed oils have a low acid value, which shows in the paint film in the form of directional brushmarks. This is also known as the "suede-effect", being similar to the brushing of suede in one direction, then another, to reveal two different marks or shades. This tendency to show brushmarks can be countered by adding a small amount of a paint medium that is self-levelling (e.g. stand oil, alkyd medium). Linseed oil is produced extensively in the Low Countries and the Baltic States of

Europe, where sunlight tends to filter through low cloud for a large part of the year, offering ideal growing conditions for the flax or linseed plant.

Refined linseed oil dries quickly (perhaps 2-3 days), sometimes causing the surface of the paint film to skin-over or wrinkle if applied too thickly. Poor quality refined linseed oil may dry even quicker: industrial products may have an inclusion of drying agent such as cobalt siccative, which may be appropriate for industrial paints, but is not desirable for artists' colours. The addition of excessive drying agent into a paint mixture causes the applied paint film to dry out too aggressively: once the paint film has seemingly dried, the drying agent continues to act on the oil until eventually, the paint film turns chalky and becomes underbound. This is not such a problem with industrial paints, where periodically, the object that has been painted requires re-painting. When the paint film turns slightly chalky, it can be easily overpainted, the mattness of the remaining paint coating providing a good grip for the new coat of paint. With artists' colours, this would be a disaster: the paint film becomes embrittled and fragile.

Herein lies the argument for purchasing artists' materials from specialist suppliers rather than hardware stores or industrial suppliers as they are more likely to offer the best quality and most appropriate choice of materials.

Cold-Pressed Linseed Oil

In the food industry, cold-pressed oils such as olive oil are highly prized and afforded the term "extra-virgin", which refers to the pedantic nature involved in pressing oil from the olive fruit. In a similar fashion, in the context of artists' materials, cold-pressed linseed oil is also produced using an exacting method, which in turn increases the cost price and limits availability to a degree. The term "cold-pressed" refers to the method of oil extraction from the seeds of the flax plant. The seeds are crushed between milling stones (as with the old method of producing flour inside a windmill) and the oil is expressed without any heat whatsoever. This form of pressing produces an oil that has a higher acid value than refined linseed oil. It is of great importance to artists wishing to prepare their own oil colours, as this high-acid value oil readily absorbs powdered pigments, so assisting the paint-making process. The pressed oil usually contains plant mucilage and other debris, so has to be cleaned before offering to the market. This is traditionally done by adding a quantity of fuller's earth into the oil vat. This diacatamous earth has a very large particle size, in a form similar to a horseshoe: this peculiar shape tends to attract debris and drags it down to the bottom of the vat, as it falls with gravity. In this way, the oil is cleaned, partially clarified and free of impurities. When the fuller's earth has settled out at the bottom of the vat, the clear oil is poured off into another vessel, then packaged. An alternative method for cleaning the oil is to mix it 50 : 50 with cold water, into an air-tight vessel. The contents are then shaken vigorously, so that the oil and water are combined. After repeated shaking, perhaps for 15-30 minutes in total, the vessel is left to stand for a period of approximately 1-2 weeks. Upon standing, the oil and water separate out: the clean oil rises to the top, while the water remains at the bottom. In between, a layer of mucilage forms. By letting the mixture stand for a prolonged period, it will be observed that more and more mucilage forms in between the oil and water. After 1-2 weeks, the clean oil is carefully poured into a new container. The whole process can be repeated a number of times, until the oil has absolute clarity. In order to remove the oil from the mucilage and water without contamination, the mixture can be frozen. The water and mucilage will freeze before the oil does. As a result, the clean oil can be poured out of the vessel without contamination.

This lengthy process results in oil that has a surprising clarity, which may help to realise brighter colour resonance.

Whereas refined linseed oil is a modern, industrial product, extensively used by other industries, cold-pressed linseed oil is utilised by artists' material companies and health food suppliers; a tiny, niche market. As a consequence, the quality of cold-pressed linseed oils available to the market may vary from brand to brand, depending on the source of production. The colour may vary, as may the debris content and acid content. The best quality oils currently on the market are sourced from Scandinavia and Germany, although the author has seen samples from Australia, United Kingdom and North America. In general, cold-pressed linseed oil has a golden yellow or yellow-orange colour. As with all vegetable oils, a colour change takes place over time, leading to a general darkening of the dried paint film, although this is not as pronounced with cold-pressed linseed oil, as with the refined type, which darkens alarmingly.

The real advantage of cold-pressed linseed oil is that it readily accepts dry powders (pigments, additive/filler material) and that when brushed out on to the painting surface, brushmarks tend to level out. Cold-pressed linseed oil will take longer to dry than refined linseed oil (perhaps 3-4 days for a thin paint film) but has a superior gloss and hardness once dried.

Upon drying, linseed oil has a tough, leathery film, with a good gloss, which should sustain over time. With certain pigments, there may be a matting, or sinking effect. This usually happens where not enough oil has been incorporated into the paint mixture: when the paint is first applied to the painting surface, it may be glossy, but upon drying it becomes less so. The best way to counter this is to add a small proportion of a painting medium to the paint (see Oil Painting Mediums), but it may be an indication that the paint itself is not particularly well made. In practical terms, such defects are rarely seen until a few months after the painting is complete. It may be wise therefore, to make a sample chart of paint-outs of one's usual palette, applied to a canvas prepared in the usual way, upon which one can easily check the performance, with age, of specific colours. The incorrect amount of pigment to oil is most usually noticed with black pigments. They may seem to be sleek and glossy when first painted, but may lose their glossiness in a short space of time and turn matt. To counter this, always add a little painting medium to black oil colours.

All oil paint films yellow (darken) with age. To an extent this is unavoidable. In the case of pale colours: whites, yellows, certain blues such as cerulean blue, it is often advised to use pale coloured oils such as poppy or safflower oil. In the short term, this can be desirable, because the paint film will be truer to the hue of the pigment used. However, over time, all the vegetable oils used as binders for oil paint tend to turn dark. While linseed oil always forms a hard, durable and glossy paint film, other oils may form less desirable films: often, the pale oils form matt films, which may attract dirt and dust. As a consequence, it may be wise to use only linseed oil, even if this means that with pale colours, the natural yellow of the linseed oil has some presence in the paint mixture.

With white pigments, this yellowing tends to show the most, especially if the paint is poorly made. If there is too much oil to the quantity of pigment, upon drying, the pigment will settle out in the mixture, leaving a thin skin of oil over the pigment surface, which reads to the eye as being yellow. This phenomenon is greater when a painting is stored in the dark, or stored away from daylight (i.e. stacked with the paint surface hidden from view). While this darkening can be countered by re-exposing the paint surface to strong sunshine for a week or so, it is an inevitable defect seen in oil paintings, especially when large amounts of white have been used.

The natural yellow-orange colour of cold-pressed linseed oil will have some presence in the paint film, even if the paint is very well made. Refined linseed oil, which has been bleached to give a very pale colour, may in the short term not effect the colour in the paint film, but over time it turns progressively darker. It may as a consequence be wiser to continue to use cold-pressed linseed oil, safe in the knowledge that although all colours will be warmed up slightly by the natural colour of the oil, they will not dramatically alter over time.

This situation is further confused by claims from some artists' material companies that their refined linseed oils do not darken excessively or change over time. The best advice for artists is to test some different oils and leave them for an extended period (perhaps 4-5 years) to gauge which option is best. While this may not seem like a practical solution, for a young artist at art school, this is easy enough to do. By the time one has finished art school, the result of the experiment is more or less complete. It would make sense if more art schools encouraged their students to experiment and test painting materials early in their courses, so that information such as that available in "text" books like this one, can be thoroughly explored and challenged where appropriate.

Refined Linseed Oil with Siccative (Oil Varnish)

As mentioned, some industrially produced refined linseed oils may already contain a drying agent such as cobalt siccative. These oils are sometimes referred to as linseed oil varnish. When used as a binder, such oils should only ever be applied thinly, as fatter passages of paint will tend to wrinkle and shrivel on the surface. Such oils may be useful for making very quick drying oil colours, where the paint needs to dry in a short period (perhaps 1-2 days). Because the manufacturer has incorporated the drying agent into the oil, such oil may be useful when making paint mediums. Rather than adding neat driers to an oil paint medium, it may be wiser to use a proprietary brand of drying oil, where the same quantity of drying agent is added to the oil, in each batch produced. Adding neat drying agent to paints and paint mediums is rather unpredictable. Unless one does this in a scientific way, with accurate measurement of the liquid drier, it is more than likely that such additions will lead to cracking or over-drying of the paint film.

Modern Stand Oil

Modern stand oil is produced by heating linseed oil in a vacuum. This process thickens the oil to the consistency of heavy syrup. It also partially oxidises the oil, so that it dries a little quicker, forms a self-levelling film and does not darken excessively. As a consequence, stand oil is often used as an addition to painting mediums, but rarely as a binder for oil paints. As a binder, it is rather difficult to manipulate, being thick and viscid in nature. While this type of thickened oil is today referred to as stand oil, it is really a type of polymerised oil, or blown oil. Somewhere along the way it was given the name stand oil, probably because in some way it resembles the historic sun-bleached or sun-thickened oils of the past.

Historic Stand Oil

Linseed oil which has been left to "stand" for a period while exposed to sunlight, is true stand oil. This is also sometimes referred to as sun-bleached oil, because upon exposure to sunlight, the colour becomes very pale and clear. The consistency of this historic form of stand oil is similar to ordinary linseed oil, it can be poured easily and is excellent for making paints. It is still available, though is highly priced, due in part to the lengthy process involved in its manufacture.

Sun-Thickened Linseed Oil

When linseed oil is exposed to both air and strong sunlight, it will become pale in colour but will also thicken to a heavy syrup consistency (similar, somewhat confusingly, to modern stand oil). This glossy, rich oil is excellent as an additive to painting mediums, especially when cold-pressed linseed oil has been used, which has been cleaned of impurities (see Cold-Pressed Linseed Oil). Sun-thickened linseed oil is prepared by pouring a quantity of oil into a flat glass tray, which in turn is exposed to strong sunlight for a period of days or weeks. During this exposure, the oil needs to receive air: a glass lid is placed over the tray, with props to let air circulate. A fine gauze or muslin can be stretched over the tray to keep insects and debris out (although these impurities can always be strained at a later stage). The oil needs to be stirred once a day for a period of perhaps 1-2 weeks. Stirring helps to stop the oil from thickening on the surface only. The oil produced in this way is light in colour but viscous: it can be incorporated into oil painting medium recipes (for example, in the place of modern stand oil). Sun-thickened linseed oil imparts a glossy, enamel-like sheen to oil colours, is self-levelling and less prone to darkening than cold-pressed or refined forms of linseed oil.

The drying time of sun-thickened linseed oil is quickened when the oil is exposed to lead during the thickening process. This can be done by laying a strip of lead in the bottom of the glass tray, with the oil covering it. Lead has a catalytic effect upon the oil. Alternatively, 10% by volume of massicot pigment is left to settle at the bottom of the tray of oil. This lead mono-oxide pigment will also impart a drying action to the oil.

Poppy Oil

Poppy oil is a delicate pale colour, with a thinner consistency than cold-pressed linseed oil. Both refined and cold-pressed varieties may be found on the market. The French painters of the 19th century used oil colours prepared with poppy oil, in part because this was the fashion of the day but also because the longer drying time (4-5 days for a thin film) enabled paintings to be worked on over longer periods. This can be seen to be especially useful when working out of doors, from nature, where a fresh, wet paint surface can be re-worked over a period of days. Because it is so pale, poppy oil reveals the true colour of each pigment ground into it. This can be especially useful with regard to pale colours: whites, blues, yellows. While this clarity of colour may be useful during the painting process, poppy oil - as with all the other drying vegetable oils used in oil painting - will become darker over time.

Oil paints prepared with poppy oil tend to form a stiffish, short buttery paste very readily. This can be helpful when learning to hand-make oil colours, as each pigment can be seen at its best (because of the pale colour of the oil) and the paint paste is quickly achieved. Also, because of the slower drying time, hand-made oil colours based on poppy oil will remain fresh for longer on the palette, or perhaps in air-tight glass jars, than would be the case with linseed oil based paint. The author has examples of slow drying colours (e.g. genuine carmine, genuine vermilion), which were hand ground into poppy oil, and which remained wet and workable for over a year when stored in an air-tight glass jar.

A particular defect of poppy oil is the matt quality of the paint film. This tends to cause the initial gloss of the paint to edge away, as the matt/dry nature of the resultant paint film is rather attractive to dust and dirt. Paintings made with poppy oil need to be stored while drying, as close to the ceiling as possible (away from dust, which gathers at floor level). The Victorians in Britain built their art schools with drying racks, high up above the studio workspace. This was not just an ingenious and rational use of space, it had the desired effect of allowing paintings to dry without coming into contact with excessive dirt and dust.

Poppy oil forms a less durable paint film when compared to linseed oil. Indeed, fat passages of oil paint made with poppy oil as the binder tend to crack rather easily when stressed.

Safflower Oil and Sunflower Oil

Safflower and sunflower oils are sometimes used within oil paint ranges, especially for white pigments. However, they suffer similar defects as poppy oil, forming relatively matt films and giving weaker paint films (especially when applied thickly), than linseed oil based paints. They dry at a similar slow rate as poppy oil.

Walnut Oil

Oil pressed from walnuts was used to a great extent in the past, especially in the context of Italian oil painting and later, in the work of artists such as Van Dyke. Because of its very pale colour and brilliant gloss, it was often preferred over linseed oil. The clarity of this oil was greatly respected, because colours ground in it revealed their true shade. Walnut oil was also important as an ingredient in egg-oil emulsions. Despite these attractive qualities, walnut oil is seldom used today for oil painting, in part because it becomes rather brittle upon drying, making it somewhat unsuitable for using on to stretched canvas (flexible support). On to rigid supports such as wooden panels, walnut oil may be an excellent binder for oil colours. It remains glassy, glossy and hard-wearing over time, lending colours excellent saturation and depth. Freshly cold-pressed walnut oil can quickly turn rancid upon exposure to air. Walnut oil dries a little faster than poppy oil (3-4 days).

Hand-Made Oil Colour

Before using proprietary brands of oil colour, it is useful to learn the process of paint-making. The factory processing of oil colours is in truth a mechanised copy of hand-made paint. Prior to the 1840s, and the invention of the collapsible metal tube, artists were required to hand-prepare their colours, perhaps even every day. In many ways, this paint-making process was an integral part of the activity of painting as a whole.

The genesis of oil painting technique can be traced back to the workshop tradition of medieval artists, where a team of apprentices or assistants would work under a “master”. All facets of painting production were achieved in such workshops, from the correct preparation of the painting ground, through the precise preparation of colours, down to the execution of the painting.

During the early 19th century in France, especially Paris, dedicated suppliers of colours and other materials for artists began to emerge, with the advent of the Industrial Revolution. On a small scale, individual suppliers began to diversify their trade to cater for a growing demand for ready-made artists’ materials. This would have included hand-stretched canvases, but also the hand-preparation of oil paints. Often such paints were prepared according to the demands of an individual artist, rather than conforming to some ideal "standard" form of oil paint. As a consequence, today we have a myriad of oil paint ranges, which differ from one brand to another, dependent to some degree on the philosophy and history of production of the factory concerned. This individuality has in recent years become less distinct, with many companies pushing through products that meet the common demand, rather than the peculiar demand of individual artists.

The author has had many intriguing conversations with artists over the years regarding the notion of the ideal oil paint. In truth, this would seem to relate more to the foibles of the artist concerned than to any higher truth. In practice, any artist can take a batch of pigment, some oil and a few other additives and make a superior quality oil paint. There is no secret to the making of oil colours, it is not necessarily a high art. It is the high cost of the raw materials used in the manufacture of oil colours that causes most artists to shy away from experimenting with hand-made oil paint: one does not want to waste money and materials. Another factor that prevents artists from experimenting with raw materials is time. The artist is preoccupied (rightly so) with achieving the image, rather than dabbling about with pigments in the hope of finding the answer to a seemingly elusive quest.

However, it can be argued that even a cursory amount of time spent paint-making can open the artist's mind to a world of possibility with colour. The best way to form an opinion about colour (and the vehicle/binders) is to take the raw materials used in painting and put them to work.

For making oil colours it is advised that a space is made within the studio which is dedicated to this activity. In effect, this entails clearing the area required and keeping it dirt and dust free. Cleanliness and organisation is paramount in this matter, as will become apparant once such work is undertaken. A table or worktop is required, positioned just above waist height, so that as little stooping as possible is necessary. On to this level worktop, the following items can be carefully laid out, so that they are easily accessible:

- Selection of dry pigments (see list – stored in air-tight glass jars, and labelled)
- Glass muller
- Glass slab, with slight tooth (sandblasted glass), or a marble slab with a slightly rough surface
- Cold-pressed linseed oil (and other oils as preferred)
- Odourless mineral spirit
- Sunflower oil (for cleaning)
- Methylated spirit (alcohol)
- Beeswax paste
- Aluminium hydrate (transparent filler)
- Blanc fix (opaque filler)
- Empty metal tubes (60ml, or 100ml)
- Paper roll for cleaning
- Waste bin
- Disposable gloves
- Dust mask

Tools and Ingredients

Dry Pigments

This basic selection of pigments offers a starting point. All the colours have good permanence, are relatively straightforward to prepare and are not too costly to procure. If possible, keep the original labels for each colour, so that in the case of an accident, the supplier can be contacted. It will also be useful for keeping a record of each colour, so that when new supplies are required, the same colour name, code number or colour index name can be quoted.

Nickel titanium yellow

Cadmium yellow light

Hansa yellow light

Cadmium yellow deep

Hansa yellow deep

Cadmium orange

Cadmium red middle

Permanent red

Cadmium red deep

Quinacridone red (permanent rose)

Ultramarine blue

Ultramarine violet

Indanthrone blue

Cobalt blue

Cerulean blue

Heliogen (phthalo) blue

Quinacridone violet

Dioxazine violet

Heliogen (phthalo) green

Viridian green

Chrome oxide green

Cadmium green

Terre verte

Oxide (mars) yellow

Raw sienna

Burnt sienna

Raw umber

Burnt umber

Oxide (mars) red

Oxide (mars) violet

Oxide (mars) brown

Oxide (mars) black

Carbon black (ivory black)

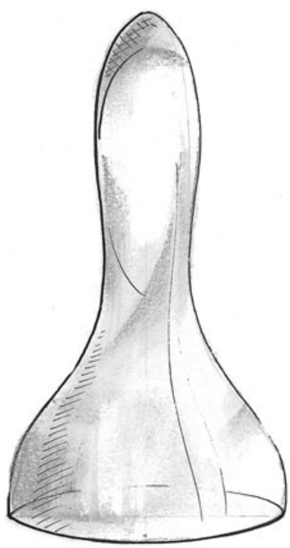
Lamp black

Titanium white

Zinc white

Glass Muller

The glass muller, or glass runner, is a round, bulbous piece of heavy glass, with a flat bottom. It may have a tall glass handle, or sometimes a "door-knob" shaped handle. The base is flat and is usually abraded (sandblasted). This grainy surface corresponds to the sandblasted surface of the glass slab, so that pigment powder caught in-between these two pitted surfaces does not dance around on the glass surface.



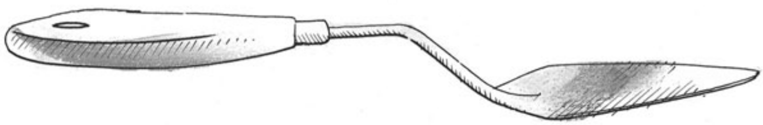
Glass Muller

Glass (or Marble) Slab

The slab, with its pitted, sandblasted surface, allows the paint mixture to be moved around without spreading out all over the glass. The pigment particles get lodged in the pits of the glass surface. The slab needs to be thick enough to withstand a certain amount of pressure. An ideal size format for the glass slab is 40 x 60cm: this is big enough to work up small quantities of pigment and is relatively portable.

Straight Palette Knives

Stainless steel palette knives, with a length of about 12-14cm are perfectly serviceable, it is not necessary to have large palette knives. The palette knives are used to help combine the initial mix of pigment and oil, and to help gather up the paint once it has been milled.



Painting Knife

Pallete Knife

Cold-Pressed Linseed Oil

The choice of oil is a personal one. It is suggested that to begin with, cold-pressed linseed oil is used as a standard binder. Other oils can then be contrasted with it.

Odourless Mineral Spirit

White spirit is now available in a form that has little or no smell. This can be used to help free pigment particles from the glass, when cleaning up.

Sunflower Oil

Cheap sunflower oil, or other vegetable oils for cooking can be obtained from food stores. These can be used to clean the slab, muller, knives etc, without the introduction of a solvent. This helps to make the workspace more pleasant and is much kinder to hands than solvent.

Methylated Spirit

This can be used to clean the glass slab and muller properly after working. A little methylated spirit will remove any residual pigment, especially with strong staining colours, such as the synthetic organic pigment phthalocyanine blue.

Beeswax Paste

This paste is used as an additive in the paint-making process, to assist the consistency of the paint and to help keep the pigment and oil adhered together. A small percentage (2%) is added to the paint mixture. If more beeswax paste is added, the paint will become waxy, thick and matt.

The paste is made by taking:

Refined beeswax	1 part
Distilled turpentine	2 parts (by volume)

The wax is left to dissolve in the turpentine for 2-3 days, until it forms a smooth paste (similar to Vaseline). No heat is required for this process. If too thick, add a little more turpentine, mix and leave to solve again for a few days.

Aluminium Hydrate and Blanc Fix

Fillers can be added to oil paint mixtures in small quantities, to improve their light refraction (light is helped to break up on the surface) and the consistency of the paint. Too much filler will leave the paint in a stodgy, unmanageable paste and create mattness and dryness in the paint film. A small amount, perhaps between 2-10% of the whole paint mixture is advised. This will vary from pigment to pigment.

Aluminium hydrate can be used with transparent colours (e.g. phthalocyanine green), while blanc fix is a heavier, slightly opaque material, which can be used with opaque colours (e.g. cadmium red). Both "fillers" are actually white pigments that possess low tinting strength.

Empty Metal Tubes

Collapsible metal tubes are sold with open ends. These can be crimped after being filled with paint, using a pair of pliers. Before putting the paint mixture into the tube, lubricate the inside walls with a little alcohol: this will help the paint to slip down the tube. The size of the tube is open to question: in practice slightly larger tubes (60 or 100ml size) are useful, because they allow enough space for the palette knife to deposit paint in through the open end.

Paper Roll

Kitchen roll, or industrial paper roll should be on hand, so that any waste residue can be quickly removed during cleaning, etc.

Waste Bin

The waste bin should be closeable, so that the waste roll or waste rags are contained at all times.

Disposable Gloves

While handling dry pigment, always use a barrier cream on the hands and forearms, so that pigment does not come into contact with the skin. It is advised to always wear disposable gloves when working with dry pigment and when processing paint. This avoids any skin contact and makes cleaning up much easier.

Dust Mask

Similarly, a dust mask needs to be worn when handling dry pigment. Because the specification for dust masks is always changing, consult the supplier as to the most appropriate. For pigments, ask for a dust mask which inhibits nuisance dusts with a very fine particulate size. Treat all pigments as potentially hazardous.

Paint-Making Procedure

The pigment is first mixed roughly into a stiff paste with the oil, using the palette knife, combining all the pigment, and so "wetting" all the particles. Difficult pigments that are fluffy or fly-away due to their light weight and fine particle size (e.g. the synthetic pigments, such as quinacridones), need wetting before they can be ground with oil. This is done by saturating the pigment with odourless mineral spirit, until all the powder is wet. Once this is done, leave to dry out a little on some absorbent paper, before mixing to a paste with the oil. The pigment/oil mixture is then ground on the slab with a glass muller in a figure of eight motion. The aim is to achieve a smooth paint, free of lumps, where all pigment particles are bound in the oil. The oil surrounds and coats each pigment particle, so that it links the paint film together.

It is best to mull a little pigment at a time, placing each freshly milled amount to the edge of the slab. When the desired amount has been milled, repeat the process. The finished paint should be "short", i.e. it stands up when manipulated with a palette knife. If the paint levels out or is too runny, simply mull in more pigment. To the oil, it is possible to add a small percentage of beeswax (2%) to give the paint a more buttery texture and stop pigment-oil separation if being stored in a tube. However, the addition of wax will matt the paint sheen and stiffen the consistency. Poppy oil produces a shorter paint, removing the need to add wax as a stabiliser.

The choice of oil to use for grinding is decided according to the drying properties of a specific pigment (see drying times). Slow drying pigments can be ground with cold-pressed linseed oil (which dries alone in up to 4 days as a thin coat). Fast drying pigments can be ground with slow drying poppy oil (5-8 days), thus achieving a balance of drying times. Poppy, safflower and sunflower oils are often used for grinding with pale yellows, delicate blues and whites. They are paler than linseed oil and less prone to yellowing, although they dry slowly and produce less durable paint films.

Some pigments, for example ultramarine blue are difficult to grind to a good, thick consistency. In such cases it is better to grind up the amount of colour needed for the painting session, then use immediately, rather than try to store it in a tube. The addition of a painting medium can enhance the adhesion of hand ground paints. A good way to do this is to place the freshly milled colour on to a sheet of absorbent paper (newsprint, newspaper, etc.) and leave for an hour or so. Excess oil is leached out of the paint mixture, leaving a lean oil paint. This can then be fattened slightly by mixing in a small amount of a glaze medium (no more than 10%), derived from stand oil/dammar varnish/turpentine.

The final paint mixture should be stiff in consistency but easy to brush out and dilute with turpentine. If the paint is too stiff, it may harden in the tube; if too sloppy, the pigment/oil may separate out, so that when the tube cap is opened, an excess of oil spurts out.

A small addition of aluminium hydrate as an extender/filler may be incorporated. This will help give the paint a homogenous, buttery texture but will increase its transparency. Up to 2% (by weight) could be added to the paint mixture. An excess will leave the paint dry and crumbly, and more prone to yellowing. Metallic soaps such as aluminium hydrate can cause oil films to become spongy and brittle with age.

The freshly mulled oil paint is best used straight away but can if preferred be stored in empty collapsible tubes. These should be labelled for identification and a small swatch of colour painted out on canvas paper, as a record for the future.

Oil Absorption

Pigments absorb oil to varying degrees. The amount of oil needed to make a stable paint paste will vary from one pigment to another. For example, the oil required to form a stable paint paste with green earth may be around 80% or more, while that of zinc white is lower, at around 15-25%. The percentage is approximate, because the product may vary in its absorption from one source to another. The percentage of oil to pigment can be expressed as the relative volume of oil to dry pigment powder required to make a stable paint paste. It follows that pigments that require more oil to form such a paint paste will exhibit a propensity to turn dark/yellow with age, due to the addition of a larger amount of oil. The dried paint film may also remain softer for longer, especially when paint is applied in any thickness. Artists wishing to work in a technique where the paint is applied with a little impasto should therefore choose colours that require the least quantity of oil in their composure.

The following outline list of common pigments found in oil paint ranges can be regarded as a starting point. When hand grinding colours, it may be wise to let each batch of paint rest on an absorbent paper for a few minutes, then remix to form a paste: if the resultant paint is too matt when dried, it then follows that more oil is required. In this way, by trial and error, one can find the right balance between pigment and oil required for a specific colour.

Where relevant, a specific oil is mentioned, as in the case of whites, where pale oils such as poppy oil may be more desirable to reduce the degree of yellowing. Otherwise, it can be assumed that the percentage figure relates to the required amount of linseed oil.

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
White Pigments		
Lead white	PW 1	20% + (poppy oil, safflower oil)
Zinc white	PW 4	15-25% + (poppy oil, safflower oil)
Lithopone	PW 5	10-20% + (poppy oil, safflower oil)
Titanium white	PW 6	15-20% + (poppy oil, safflower oil)
Blanc fix	PW 21	10-20% + (poppy oil, safflower oil)
Alumina hydrate	PW 24	*

* Never used alone for paint making, as it shows the colour of the oil too readily and gives too soft a paint paste. Only added as a filler/extender, in small quantities (e.g. up to 10% of whole paint mix).

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Yellow Pigments		
Massicot	PY 46	25%+
Cadmium yellow	PY 35, 37	40-60% +
Hansa yellow	PY 1, 3, 65, 73, 74	50% +
Chrome yellow	PY 34	30-60%+ (poppy oil, safflower oil)
Cobalt yellow	PY 40	30-40% + (poppy oil, safflower oil)
Naples yellow	PY 41	20-40% + (poppy oil, safflower oil)

Nickel Titatium yellow	PY 53	15-20%
Zinc yellow	PY 36	40% +
Lemon yellow	PY 31	15-20% + (poppy oil, safflower oil)

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Red Pigments		
Red lead	PR 105	20% +
Studio red	PR 3	50-70%
Chrome red	PR 104	40% +
Carmine	NR 4	60-80% +
Madder	NR 9	60-75% +
Alizarin crimson	PR 83	60-75% +
Cadmium red	PR 108, 113, PO 23	40% +
Vermilion	PR 106	25% +

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Earth Pigments		
Raw umber	PBr 7	70% + tends to vary according to type
Burnt umber	PBr 7	70% + tends to vary according to type
Raw sienna	PBr 7	100% + tends to vary according to type
Burnt sienna	PBr 7	50-200% + tends to vary according to type

Yellow ochre	PY 42, 43	50-60% + tends to vary according to type
Green earth	PG 23	80% + tends to vary according to type
Van dyke brown	NB 8	200-250% +

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Synthetic Iron Oxide Pigments		
Mars yellow	PY 42	65-70% +
Mars red, violet	PR 101, 102	30-70% +
Mars black	PBk 11	50-60% +

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Blue Pigments		
Phthalo blue	PB 15, 16	30-50% +
Prussian blue	PB 27	60-120% + (poppy oil, safflower oil)
Cobalt blue	PB 28	120-140% + (poppy oil, safflower oil)
Ultramarine blue	PB 29	30-50% + (poppy oil, safflower oil)
Manganese blue	PB 33	30% + (poppy oil, safflower oil)
Cerulean blue	PB 35	120-140% + (poppy oil, safflower oil)
Cobalt violet dp.	PV 14	100% +
Manganese violet	PV 16	20-30%+
Cobalt violet lt.	PV 47	100% +
Cobalt violet br.	PV 49	100% +

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Green Pigments		
Chrome oxide	PG 17	30% +
Phthalo green	PG 7, 36	30-45% +
Cobalt green	PG 26	70% + (poppy oil, safflower oil)
Viridian	PG 18	50-100% +

Pigment	Colour Index Number	Approximate Oil Required in % with Dry Pigment
Black and Brown Pigments		
Lamp black	PBk 6	100-800% + *
Ivory black	PBk 9	50% +
Manganese black	PBk 14	30% +
Vine black		50-120% +

* Particle size is extremely small and therefore may require excessive amounts of oil to provide a stable paint film. It follows that lamp black only successfully dries when applied in flat layers, rather than with impasto.

Working With Pigments

When handling dry pigments, take care not to breathe in pigment dusts (wear a dust mask) and avoid using toxic pigments without adequate protection (mask and gloves).

Take particular care when handling lead-based pigments, such as lead white.

Do not eat, smoke or drink when working with dry pigments. Keep all materials out of the reach of children. Prepare materials only for intended use. Before handling dry pigments and also solvents, rub a good quality barrier cream into the hands and wrists. This will help prevent absorption of pigments into the skin and will assist when cleaning colour from hands and skin after painting, etc. If possible, wear protective gloves when preparing pigments into the binding medium to help prevent contact between pigment powder and skin. Label all dry pigments, so that they can be identified in case of accident. Keep a record of the supplier, code number and supplier phone number and address. When cleaning up residue of paint pigment after working, wipe excess on to absorbent cloth or paper. Avoid emptying waste paint, etc into sink, as this can clog and contaminate drainage. It is also a potential offence to dispose of coloured and/or possibly toxic materials in this manner. Dispose of all toxic materials, (including old tubes, containers, bags) responsibly. Contact local authority for further advice on disposal.

Toxicity of Pigments

This table covers some pigments mentioned in the text but includes others that are available either as prepared oil colour and/or as dry pigment. Due caution is advised when handling any pigment in dry form.

Pigment	**Potentially Toxic Composition**
Chrome yellow	chromate of lead
Naples yellow	lead
Indian yellow imit.	nickel
Nickel titanium yellow	nickel
Cadmium yellow, orange	cadmium sulphide. Cadmium is toxic when burnt. Cadmium pigments can also contain a percentage of barium sulphate
Cadmium red	cadmium sulpho-selenide. Cadmium is toxic when burnt. Cadmium pigments can also contain a percentage of barium sulphate
Lead red	lead tetroxide

Vermilion	mercuric sulphide
Manganese blue	barium manganate
Cobalt blue	cobalt oxide
Phthalocyanine blue/ green	copper
Cobalt violet	cobalt oxide
Manganese violet	manganese
Cerulean blue	cobalt oxide
Cobalt green	cobalt
Lead white	lead carbonate
Lithopone white	barium
Blanc fix (extender)	barium

Further advice on use of materials may be available from the supplier or manufacturer.

Manufactured Oil Colour

Oil colours are sold according to a curious form of grading. High quality colours may be referred to as "Professional" or "Classic" oil colours; "artists' quality" is another term applied to high quality oil colour. By contrast, the determination of lower quality colours is more difficult to explain. "Student" or "Sketching" oil colours are sometimes referred to. This calls into question the role of the student: does every student have to work with poor quality materials? No, this is a kind of insult for all students, many of whom aspire to work with the best (or perhaps most appropriate) materials. Similarly it is not a crime to make a sketch, so perhaps the term "Sketching colours" is similarly invalid.

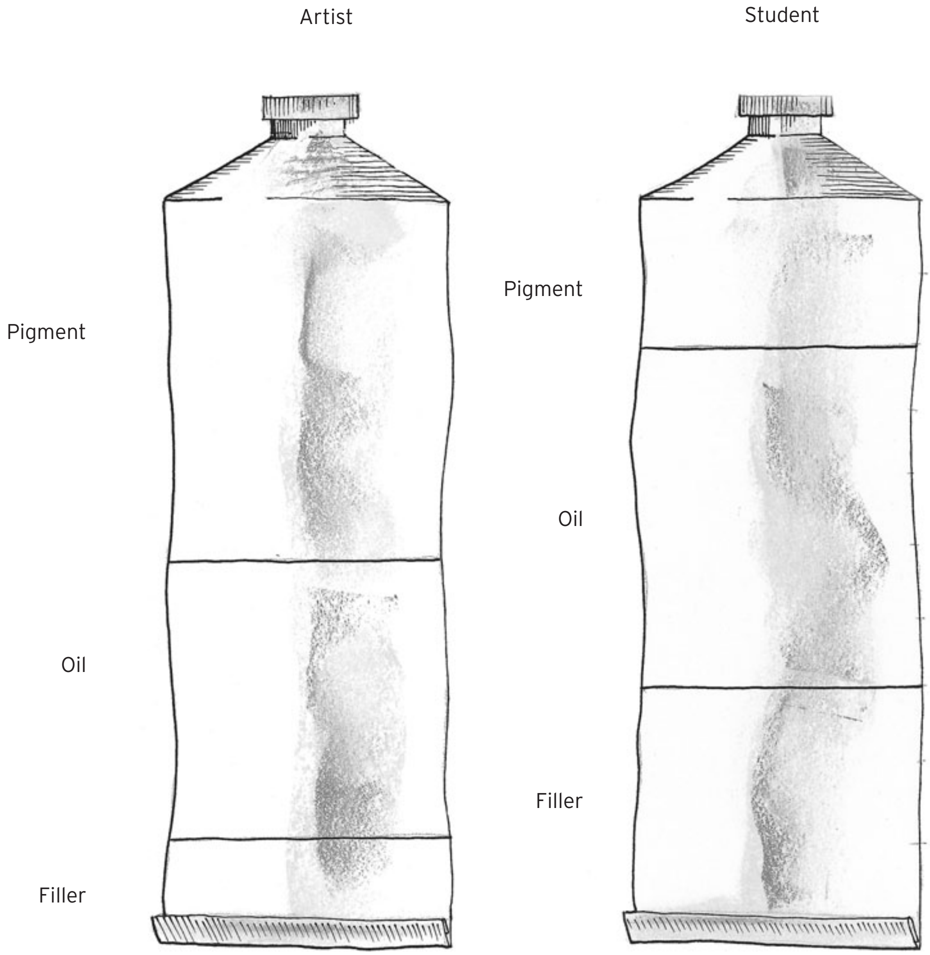
The proof of the pudding is always in the eating. In practice, there are many differing qualities of oil colour on the market: some high priced paints are not good when compared to some lower priced products, and so on. The only true test is to procure a number of colours from different brands and to place them against each other, admixing each with white and noting the results.

Manufactured oil colours tend to be of a higher quality dependent on:

- Quality of raw materials used (pigment, binder, additive)
- Length of time spent processing the raw material
- Exactitude of balance between the raw materials used
- Intention within the marketplace

Wherever possible, only the highest quality pigment is used in the manufacture of artists' quality oil colours. This determines that fugitive pigments, or pigments that are reactive, are excluded from the paint range. There are some notable exceptions to this. For example, the author continues to use factory-made genuine vermilion, because of its particular colour quality, despite the fact that vermilion is known to darken in certain circumstances. Many artists still use alizarin crimson, despite the fact that it is known to fade and that superior equivalent pigments are also available (e.g. quinacridone red). Where the market continues to demand the use of questionable pigments, some manufacturers continue to supply. Just like any other industrial product, there are good and bad qualities of pigment. Some, which are classified as permanent, may be sold strongly diluted in tinting strength, because the manufacturer is selling them into a market that does not require absolute permanence. For example, gloss house paints need not last forever, they are periodically replaced. Some pigments may be adulterated with dye, or filler material. In the case of poorer quality oil colours, often excessive filler is introduced to make the colour go further. Because aluminium hydrate is relatively transparent when used as a filler, it can be employed to cheapen a colour, providing bulk quantity but not quality. Sometimes, the raw pigment is mixed with a filler material before it is sold.

In an ideal world, high quality artists' paints are made using only high quality pigments and other materials of a similar bias. As a consequence, the cost of these raw materials may be a factor in the pricing of the end product. For some manufacturers, the problems of maintaining the supply of traditional pigments (e.g. earth pigments, expensive metal-based colours such as cadmiums, cobalts, etc) have led them to re-align their colour ranges to make best use of modern, inexpensive pigments. For example, phthalocyanine blue and phthalocyanine green (also known as phthalo blue/green) are extremely strong pigments in terms of their tinting strength. They can be used to make reasonable imitations of cobalt blue and viridian, two relatively expensive metal-based pigments.



Comparison of Artist and Student Oil Colours

This is especially the case with lower quality oil colours, where labels often refer to "cadmium yellow hue", or "cobalt blue hue". Such colours, referred to with "hue" or "imitation", are matches to the original colour using other pigments. In this way, manufacturers have created a whole palette of "nearly" colours – ones that look a little bit like some traditional colours. These do offer the artist an alternative to high-priced colours, but rather detract from the potentially interesting qualities of the modern pigments that have been used. For example, at full strength, phthalocyanine blue is deep, saturated, extremely intense, almost a blue-black in the mass tone. However, when used to imitate cobalt blue, it is usually admixed with a little ultramarine blue and zinc white, and may include a filler such as aluminium hydrate to reduce its supreme tinting power.

By tradition, artists' oil colours are processed in factory conditions on a special milling machine, referred to as a triple roll mill. This consists of three cylindrical drums, ideally made from granite, which rotate at different speeds and in opposing directions. Prior to processing through the triple roll mill, the raw materials are combined together loosely, in a large vat, where the contents are slowly stirred together. This pre-mixing ensures that all the dry raw ingredients are dispersed into oil before being put through the roll mill. A quantity of colour (the loosely mixed paint paste) is deposited on to the top cylindrical roller; two other rollers are positioned below. The gap between the three milling cylinders is extremely small, perhaps a few millimetres. The rotation of the rollers causes the paint to be forced down between them, finally dropping out into a collection vat positioned below. Each time the paint mix is passed through the rollers, the mixture becomes finer and smoother. In effect, this milling process imitates the action of the glass muller when hand-making oil paint. Each pigment particle becomes coated with oil and any clumping together of dry material is eradicated, so that pigment particles are evenly spread within the paint mixture. After being passed through the rollers perhaps 3-5 times, the paint mixture takes on a regular, buttery consistency and the pigment particles cannot be seen by the naked eye within the oil and other additive ingredients.

It is the case with some brands and for certain colours, that special swelling agents are added to the paint mixture. One of these is a product known as Tixogel, a form of bentonite. Tixogel swells in linseed oil, forming a fat, short paste consistency. The use of Tixogel and similar products is not uncommon in the manufacture of oil colours: it is very useful to be able to create a thick, stable paint consistency by adding a small amount of such an additive to the other raw materials. Another additive used to control the paint paste during manufacturer is aluminium stearate, a metallic soap, which forms a kind of gel when worked with linseed oil. Again, this "gel" formula provides a balanced consistency, counteracting the nature of pigments that do not readily form into a workable painting paste. In cheaper colour ranges, the use of such additives may be more pronounced, so that the consistency of all the colours in the paint range are governed by the use of this gel formula, or by the addition of a swelling agent. A fundamental division can be made between high quality oil colours, (where the use of additives is kept to the bare minimum) and cheaper colour ranges, whose consistency, tinting strength and permanence is controlled (perhaps compromised) by an excessive use of additive material. Within high quality oil colour ranges, the aim is to work with each pigment to provide the optimum realisation of that particular pigment. In this context, the amount of additive material included is carefully controlled, in order to ensure that the quality of the final colour is true to the nature of the pigment used.

In many paint ranges, a number of colours may be based on admixtures of more than one pigment. If two pigments are put through the triple roll mill to make a mixture, that mixture will always be more intimate and therefore colour-resonant than one made on the palette between two colours. In effect, when two pigments are processed through rollers, they are cleaved together, so that the pigment particles mingle together in extremely close contact. This is best seen with mixtures based on whites, especially zinc white. Because zinc white affords a certain transparency to paint films, it can be put with other pigments to make subtle tints, especially with other transparent or semi-transparent pigments. Such mixtures have a degree of brilliance and radiance about them. Indeed, in some paint ranges they are referred to as “radiant” tints.

With reference to colour theory, mixtures of light rays are deemed to be additive mixtures. By contrast, mixtures with coloured particles (i.e. pigments) are designated as being subtractive mixtures. Whenever two or more pigments are mixed together, the result is a subtractive mixture. In real terms, these tend towards dullness, greyness. This is best seen when four or five pigments are combined, especially when opaque white, or other opaque pigments are included in the mixture. This effect is more pronounced when hand-mixing colours on the palette. Nevertheless, it follows that most manufacturers keep mixed colours (using more than one pigment) to a minimum of two or three individual pigments, in order to retain a degree of brilliance and radiance in the paint film.

Oil Paint in Stick Form

A number of brands of oil paint in stick form have recently been introduced to the market. A drying oil is combined with pigment and a blend of waxes, to form a crayon which can be applied to the painting support directly, held in the hand. Some oil sticks are based on a combination of beeswax and synthetic waxes, while others may be based on a beeswax and carnauba (plant) wax. Some oil sticks contain drying agents, so that the tip of the crayon skins over when not in use. However, other brands are available which do not contain drying agents, being affected only by the properties of the pigment used. This type may be more suitable, when intermixing with hand-ground oil colours with comparable drying rates. The wax-oil formulation is designed to be flexible, so that oil sticks can be applied to stretched canvas. In theory, they can be used in conjunction with oil paints, although as mentioned, the drying properties of the chosen brand of oil sticks may be a concern. It may be prudent to remember when mixing with oil colour, that the wax content in the oil stick is soluble in turpentine and white spirit. Oil colour mixtures that include these solvents can disturb adjacent applications of oil stick. Similarly, the application of picture varnishes containing turpentine or white spirit, can disturb dried layers of oil stick.

Building an Oil Painting

Because there are no standards or rules for making an oil painting, it would be unwise to suggest that artists have to follow any particular method in order to achieve the desired image. However, there are a number of concepts, common within oil painting practice, that are held with some trust both by artists and the conservation world. In short, oil paint layers are required to correspond to each other, this includes the connection between the painting ground and support; painting ground and first layer of oil paint; first layer and second, and so on. If one of these layers is inconsistent with the layer to which it connects, it may lead to a weakness or incompatibility within the structure of the painting. For example, if a thin layer of paint is applied over a thick layer, where the thick layer is still wet, upon both layers drying, the top (thin) layer may crack. This is because the thicker layer, as it dries out may change in density and elasticity, and the attached top (thin) layer moves with the thicker one. If the thin layer is so stressed, it may crack or split eventually. Such fine divisions between paint applications may be hard to gauge and control while working. As a consequence, it is advised that certain basic concepts are held on to during the working process, so that paint is applied according to sound technique.

The ideal structure for an oil painting involves a careful consideration of the painting ground and the support on to which it is applied. The ideal surface is a priming ground which equalises the surface of the support. In the case of canvas, this would involve losing the grain or texture of the canvas, so that oil paint layers applied over the painting ground lie down flat and evenly. The choice of priming and its application will alter depending on the nature and texture of the painting support (canvas, panel, etc). In ideal terms, the painting ground is even in its application, equalises the support and has a slightly absorbent surface. This absorbency is a key ingredient in the context of paint technique. For example, if the painting ground (priming) is non-absorbent, oil paint will stay on the surface and over time, will become more likely to shear away (cleave) from the ground. Ideally, the first coat of oil paint needs to absorb slightly into the painting ground, to provide a locked, keyed surface. As a consequence, many brands of acrylic primer on the market today, aim to imitate the nature of traditional semi-absorbent historical painting grounds. For example, products that are sold as “acrylic gesso primer” may be relatively more absorbent than those marked as “acrylic primer”. The term “gesso” usually implies that the priming has some absorbency (in the same way that gesso made from chalk and glue is absorbent). However, there are no hard and fast rules relating to such priming and artists need to satisfy themselves that a priming is semi-absorbent prior to overpainting with oil colours. The best way to do this, is to take a teaspoon of artists’ quality oil colour and dilute it with one teaspoon of solvent (e.g. turpentine). The thinned oil paint is then applied to the painting ground, using a flat hog varnish brush. Make a number of tests in this manner on to different painting grounds. Ideally, the paint should absorb slightly, leaving the finished paint film slightly matt, but not chalky matt. If the ground is too absorbent, the paint may appear very matt, even underbound and powdery. By contrast, if the painting ground has little or no absorbency, the paint film will stay glossy and show brushmarks, because it has not been allowed to sink slightly into the painting ground.

A perfect ground for oil painting, is to apply one coat of egg tempera over a traditional chalk-glue gesso priming. On to this surface, oil paint slightly absorbs, forming a solid bond between the oil paint and tempera layer. Because underpainting in tempera is a technique from the past and often a nuisance, or irrelevant to modern artists, few artists today bother with such a formula. However, for the sake of comparison, if one has time, it may be a good idea to try this method once. In practical terms, if the modern (e.g. "acrylic gesso") painting ground has the desired degree of absorbency, then oil paint layers can be successfully applied in an integrated manner.

If the first coat of oil paint is applied to the painting ground in a slightly dilute form (mixed down with a solvent such as turpentine), subsequent paint layers may contain less solvent. By tradition, one works from lean to fat paint. This concept, "fat over lean" relates to the oil, or oil-medium content within the paint. For example, the first layer is usually diluted with a solvent. This corresponds to a "lean" layer of oil paint, in that it is both thin and dilute. Consequently, this layer dries with a relatively matt finish, especially when applied to a gently absorbent ground. Whenever solvent is added to neat oil paint, it takes away some of the natural sheen/gloss of oil colour. In effect, the oil content is diluted, controlled in such a way as to lose its greasiness, its glossy sheen. In the first paint layer, this lack of gloss is an advantage: it means that the next coat has a slightly matt surface to grip to and matt coats provide better adhesion than glossy coats. Linseed oil as a binder is a poor adhesive, when layers are gently laid down on to each other they will form a consistent whole. However, if a thinned, dilute layer of oil paint is applied on to a fatter, glossier layer (without dilution), there is a discrepancy between one layer and another in terms of its adhesion. Consequently, it is advised to work from lean (dilute, thin) layers up to fatter (oil rich, oil-medium rich) layers. Each time a layer with progressively more oil or oil-medium is applied over a previous layer containing less oil a degree of stability is imparted into the paint film.

In practice, this works best if one keeps to the following procedure of layering:

1. Oil paint over ground layer: dilute with solvent 1:1.
2. Neat oil paint, without dilution.
3. Neat oil paint, plus 10% oil-medium (e.g. dammar/stand oil based medium).

In combination with this procedure, colours that are naturally fast drying, such as lead white or raw umber can be used in the first layers of oil paint. These layers will dry quickly, providing a sound foundation over which further coats can be applied. Where slow drying colours are used, these need to be limited to top coats, or combined with a paint medium that has a siccative (drying) effect on the paint layer.

Most problems occur when the first layers are too dilute, or when the first layer takes too long to dry and is applied too thickly. If the first layer is extremely dilute, it can become underbound, so that the paint film is actually powdery on the surface. This may happen if the painting ground is too absorbent, or if the paint film is too strongly diluted. To counter this, before painting, make a series of test paintings on to different grounds, using the same oil paint diluted with different amounts of solvent and wait to see how each one dries, before proceeding.

The problem of the first layer being too thick is easily countered, by astute dilution with solvent. Each colour may behave differently, according to its consistency and how it brushes out. Some oil paints are very stiff and require some manipulation prior to application. Others are ready to use from the tube and dilute readily. In truth, both situations may occur even within the same paint range, so one has to be prepared to manipulate the paint at all times. In any case, it is better practice to administer some control over the paint mixture before application to the painting, rather than applying paint and then trying to re-work it on the painting surface.

The table of drying rates of pigments (see pages 301-304) gives an indication of the relative drying times of pigments ground in oil. From this table it can be understood that faster drying colours need to be employed in the first layers of the painting, so that once dry, they can be safely overpainted without leading to cracking or splitting of the paint film. However, many modern oil paint ranges dry within a specific time period. The manufacturer may have added drying agent to all colours, so that they possess a similar drying time ratio. The only way to establish this, is to make some test paint-outs and to record how long they take to dry. Even when drying agent has been added to a paint, some caution is required in terms of the application of colour. True, all colours may dry in a specific time period (e.g. 7 days), but this drying time will relate to oil paint applied in relatively thin, or rather "flat" layers. Paint applied in fat, thick layers will always take longer to dry and this needs to be borne in mind at all times. Also, thicker passages of paint will dry on the surface before they dry through at the core. Consequently, pigments that have no drying effect on the oils they are ground with (e.g. alizarin crimson) may stay wet and squidgy under the surface for a considerable time. It is important in these instances not to overpaint such fat layers with faster drying colours.

Upon drying thoroughly, linseed oil changes to form linoxin, a hard, dry, but still flexible film. While drying, the oil remains susceptible to disturbance by solvent action. This is most commonly seen when one (undried) layer is overpainted with a solvent-rich layer, perhaps where the brush used in this process somehow agitates the previous paint layer, allowing solvent to re-activate it. This is seen by the eye as a leaking of colour from one layer to the next. This tends to happen when one layer is part-dried or seemingly dried but below the core is still slightly wet.

To counter this, artists can choose two options:

1. Wait for each paint layer to dry before proceeding.
2. Only work wet into wet oil paint "*alla-prima*" (at the first).

Option 1 conforms to the perfect model of an oil painting, where each layer is allowed to dry out before overpainting. This works well when working in thin, flat and even layers, especially where a reliable oil paint medium is added progressively into each layer. Some oil paint mediums that contain a drying agent can be particularly useful in this context. For example, alkyd resin based mediums, containing a percentage of drying agent, make excellent fast-drying paint mediums. Alkyd resins tend to give flat, even, self-levelling paint films and can also control the relative drying time of each paint layer. Once each thin layer of paint alkyd medium is dry, it can be overpainted successfully. Because the drying time is short (perhaps 3-4 hours), it is possible to work quickly, building up thin, even layers.

Option 2 is slightly more hit and miss, but basically affords the possibility to make paintings in one working session which can involve different thicknesses and drying times, without subsequent defects such as cracks or splits within the paint film(s). When paint is applied *alla prima*, in theory all colours join together and dry together: they are locked together and work with each other. However, if further layers are overpainted, perhaps after one or two days, there will be a discrepancy between the first mass of paint and subsequent ones. *Alla prima* painting refers to paintings that are made at one sitting. This is an ideal solution for portrait painting, where paint is applied during a working day of perhaps 6-7 hours. Similarly, to the landscape artist, working outdoors, colour can be applied quickly and freely, without fear of technical problems later. However, if an *alla prima* sketch or study is then worked over at a later stage, there may be a lack of consistency between the paint applied *alla prima* and that applied later. A variation on this technique, is to use hand-ground oil paints, where all pigments have been prepared with poppy oil, which takes longer than linseed oil to dry off. This provides a longer open working time to finish the painting and allows one to come back to the painting for a series of days or sessions, rather than having to complete the painting in one session. Be wary however, of manufactured oil colours prepared with poppy or other slow drying oils such as safflower. Often the paint has a drying agent included and the oil has been used more for its pale colour than its slow drying properties.

Another solution to the drying time question, is to underpaint with colours based on linseed oil and then work on later layers using colours based on poppy oil: in this way, the final layers will take longer to dry out than the underpainting.

Upon complete drying, oil paint films close over and prevent oxygen from entering the paint layer. Once completely dry, it is often suggested that oil paintings be given a coat of varnish, which acts as a protective layer, but this may also change the sheen appearance of the paint film.

The application of varnishes is fraught with problems and it is suggested that instead of applying varnish to oil paintings, artists instead consider using a paint medium during the painting process, which contains a resinous component. This will impart some gloss and also a degree of protection to the final paint layers. In the context of the ideal painting, such oil paint mediums are applied in small concentrations (about 10%) to the paint paste. This is enough to impart a degree of change in sheen appearance, perhaps also a little flexibility to the paint layer and to harmonise the visual impact of the paint layer.

Drying Rates of Oil Colours

Some pigments (e.g. raw umber) act upon the drying oils in which they are ground, speeding up the drying process. Conversely, other pigments (e.g. zinc white) have no drying action whatsoever. To accommodate these extremes, paint manufacturers may add small amounts of drying agents to paint formulae, so that all their colours are touch dry within a certain period.

Other colourmakers prefer to adhere to the characteristics of the pigments used, adding no drying agents and allowing the artist to decide when to apply certain colours and introduce drying mediums during painting. The manner in which oil colours dry governs their application. Oil paint can be applied in thin layers: each layer needs to dry out before subsequent ones are applied unless the painting is made *alla prima*. When oil colour is applied over previously layers that are still drying, there is a danger that the top coat will sink. This sinking process can continue for months or years after application - oil paintings can take up to 100 years (and longer, depending on the thickness of application) to dry thoroughly. Similarly, fast drying colours applied over slow drying colours may take months or years to show defects. To counter these problems, an understanding of the drying effect of the pigments used in oil painting is useful. Sound practice is to begin painting with lean colours (i.e. oil paints with a low oil content), which are fast drying. Avoid the use of 'fatty' mediums during underpainting. Raw umber and lead white linseed oil colours dry quickly, they also have a catalytic effect on other colours. Underpainting can be carried out by admixing either of these two colours with other fast drying oil colours. The following table of drying rates refers primarily to the characteristic of the pigment when ground in linseed oil only, rather than prepared oil colours. A manufacturer may add drying agents and other additives to the formulae, or introduce slower drying oils in some cases, to obtain a paint range with appealing drying qualities.

COMPARATIVE DRYING RATES OF OIL COLOURS

FAST (ideal for underpainting, or admixtures in underpainting)

Chrome yellow

Naples yellow (genuine)

Raw umber

Burnt umber

Lead white

Prussian blue

FAST TO MEDIUM

Manganese blue

Cobalt turquoise

Cobalt violet deep

Manganese violet

Cobalt violet light

Cobalt green

Cobalt bottle green (dark)

Manganese black

Cobalt blue*

Chrome oxide

Burnt sienna

Raw sienna

Spinel black

Spinel phase pigments

Priderit yellow

* Pigments containing compounds of cobalt, manganese (raw umber) and lead are good driers in oil. However, when a colour is prepared with a slow drying oil, as can be the case with cobalt blue (often ground in poppy oil), the drying effect is not as apparent. Whites and blue pigments are often ground in pale, less yellowing oils such as poppy, safflower and sunflower oils.

MEDIUM

Barium lemon yellow

Mars colours

Transparent iron-oxides

MEDIUM TO SLOW

Green earth

Yellow ochre

Ultramarine blue

Phthalocyanine blue

Phthalocyanine green

Quinacridones

Cerulean blue

Viridian

SLOW

Cobalt yellow

Alizarin crimson

Titanium white

Hansa yellow

Cadmium yellow

Nickel titanium yellow

Irgazin yellow

Paliotol yellow

Indian yellow (imitation)

Hostaperm orange

Isoindoline orange

Titanium orange

Studio red

Permanent red/Permanent carmine

Scarlet red

Paliogen maroon

Indanthrone blue

Alizarin violet

Dioxazine violet

Cadmium green

Quindo green gold

SLOW - VERY SLOW

Zinc white

Lithopone

Cadmium red

Natural madder

Vermilion

Lamp black

Vine black

Ivory black

Oil Painting Whites

Most manufacturers sell more white than any other colour, especially in the case of oil paint. The use of white in colour mixtures is very common among artists, yet many have little understanding of the merits of each white and why one should be used as opposed to another.

A simple test is to take titanium, zinc and lead white and mix a small quantity of each, in turn, with ultramarine blue. The relative transparency/opacity of each white is then easily understood. Keep this colour mix sample in the studio as a point of reference.

Titanium White

Despite only being available to artists since the late 1920s, titanium white is commonly used and accepted. It is a strong true white, with incredible brilliance, when used alone. However, when other colours are admixed with titanium white, they tend to become muddy, dead in appearance. This deadening effect is due to the fact that titanium white is an intense, covering (hiding) pigment. It tends to take over in colour mixtures, being dominant and devaluing the subtleties of other colours. This is especially so with transparent colours, which all but disappear when mixed with it.

Used alone, however, titanium white affords brilliant reflectance. It is the ideal white for use in painting grounds, where it provides the optimum bright white background, upon which light rays refract strongly. When thin veils of transparent colours are overpainted on primings made with titanium white, light rays pass through the transparent applied colour and hit the bright white ground. The light rays are then rebounded back through the transparent applied colour to the eye, affording maximum luminosity to the perceived colour of the paint layer.

Titanium white, when ground with linseed oil forms a relatively brittle paint film, especially so when applied thickly.

Zinc White

By contrast to titanium white, zinc white is semi-opaque: it has a degree of transparency. As such, when admixed with other colours, it tends to make subtle half-tints, pastel shades, where the original colour has a great presence. This is especially so with transparent pigments, whose delicate nuances of hue remain intact when carefully combined with zinc white. It has a slightly bluish tinge, which may give a certain coldness when used alone, or when mixed with pale colours.

Zinc white, when ground with linseed oil forms a relatively brittle paint film, especially when applied thickly, where the paint film may form characteristic “slash” cracks upon drying. In any case, zinc white is best used in thinner applications, to make subtle glazes with other colours.

Lead White

If zinc and titanium whites form relatively brittle paint films, by contrast, lead white provides more flexible films, even when applied with a slight impasto (perhaps up to 1cm thick). Lead white has a warm tinge when ground in linseed oil, which can be helpful when mixing with other colours to make half-tints. Although not as transparent in nature as zinc white, lead white does make acceptable admixtures with other pigments. Also, because it dries quickly in linseed oil, lead white can act as a carrier for slow drying colours. If one makes a series of half-tints based on lead white (e.g. with lamp black, indanthrene blue, cadmium yellow, cadmium red, etc), those half-tints will dry off quickly (perhaps 1 day for a thin coat). This makes lead white ideal as an underpainting white, where all colours mixed with it will take on its characteristic. The paste consistency of lead white oil paint is also desirable: it is a soft, buttery paste, which is especially useful for admixing with transparent colours that are oil-rich (e.g. green earth), to control their paste-consistency. Lead white is especially prized among portrait painters, where a good paste quality, quick drying time and kind harmonious strength with other colours is required. It can be seen in historical paintings that areas of paint that contain lead white tend to contract, or shrivel, less than areas that do not contain it. This is especially so in areas of impasto: where these parts are modelled with lead white, there is little change in the shape or form of the paint film. By contrast, areas of thick paint, which are made just with colour, may have changed shape and form dramatically.

Despite its toxicity, lead white is still asked for by artists and remains a crucial component colour in the traditional painting palette.

When lead white is ground with linseed oil, it is often referred to as underpainting, or foundation white. In linseed oil it dries quickly: as a consequence it is sometimes used for the priming ground, or to make a tinted ground with another colour, which will be fast drying.

The term "flake white" is also often used in connection with lead white. Flake white is the name most often used when lead and zinc white are mixed together.

Lead white may darken on exposure to sulphurous compounds in the atmosphere. While this was a common problem in the 19th century and early 20th century, due to the amount of coal fires being used in cities, today this is less of a problem. To protect oil paintings from exposure to sulphurous fumes, paintings were often varnished so that the paint film was closed off from the environment. This may partially explain a neurosis among artists that all paintings have to be varnished upon completion. The opposite may be more true today: because sulphurous compounds in the air are now minimal in Western Europe, paint films need not be so comprehensively protected from the immediate environment.

In accordance with EU law, lead white is now sold according to certain restrictions, which are liable to change with time. While at present this pigment is still available to artists, this is a situation that may change. Because of its historical importance, artists wish to continue to use lead white: it is a pigment that possesses many preferred qualities and remains an integral part of many artists' palettes.

The Oil Painting Palette Explained

The genesis of the painting palette is worth some consideration prior to beginning work. The organisation of colours on to the palette is a matter of some importance. Prior to the invention of the collapsible metal tube in the 1840s, artists were required to pre-mix and lay out the colours required for each painting session. In these circumstances, the exact layout and order of preference for each colour was important. For example, core colours could be laid out around the top edge of the palette, while half-tints and special mixtures might be laid along the bottom edge. A study of artists' palettes through the ages would reveal a myriad of possibilities for arrangement. Despite this, most artists laid out their colours according to the demands of the subject. For example, portrait painters would be required to have ready-mixed flesh tints to hand once the painting session began. In this way, no time would be wasted adjusting colours while the sitter was present in the studio. In accordance with this, many artists adopted a rationalised approach to the layout of their colours: perhaps 4-5 pale flesh tints, followed by a similar series of darker tints, some tints for highlights and so on. The crucial element here is that prior to painting, the artist would have all these tints pre-mixed and they would be placed at strategic points within the palette, rather like a piano keyboard.

For the modern artist, the situation is different: modern tube colours can be readily squeezed out as required. However, most colour ranges feature very few pre-mixed half-tints, so before working, the raw, neat colour requires some manipulation (e.g. with white) prior to painting. Some facets of previous times remain within paint ranges. For example, most ranges feature a "flesh tint", yet the exact shade of this flesh tint will be different from brand to brand. In practice, rather than relying on the idea of a colour as governed by the paint factory, the artist is required to take the neat pure colour and make mixtures to afford the colours required.

The main difference is that in previous times, the artist would prepare the colours from the raw materials, or, if lucky an apprentice would do this task. As a consequence, the artist made enough paint for that painting session - this could entail making a composite colour, which included more than one pigment, oil and also a paint medium. In this system, all the raw materials are combined at the beginning, rather than is the practice of today, where tube colours are put with each other, then admixed with a paint medium. The main practical differences here seem to be the resonance of the mixed colour: it is always better to hand-grind pigments together with oil, rather than mix two tube colours together. One can make a truer, more intimate mixture using the former technique. Also, one preserves the exact nature of an individual pigment. With modern paints, the "colour" may in fact contain more than one pigment, plus filler/additive material.

The palette is by tradition a kidney-shaped or rectangular shaped piece of wood, normally a hardwood such as mahogany. Some palettes were weighted at one edge, so that when standing to paint, they could be easily held. Traditionally, palettes have a thumb hole in their structure so that they can be held, supported by the forearm and hand, against the body of the artist. Modern wooden palettes are often simply varnished plywood, dyed to imitate the appearance of harder woods. In practice the raw wood should be treated with linseed oil, so that it becomes non-absorbent. This involves applying perhaps 3-4 coats of oil, rubbed into the surface to gradually reduce its absorbency.

The dark colour of the wood may be a disadvantage to modern artists, who tend to work on to bright white grounds, rather than the dull toned grounds of the past. For this reason and also for reasons of practicality, it may be more relevant to the modern artist to use a sheet of glass as a palette. The glass sheet or plate needs to have sanded edges, so that there is no risk of cuts to the hands. It is placed on to a worktop, with a sandwich of white paper between the glass and the work surface. This imitates the white ground of the painting support, thereby allowing colour mixtures to approximate how they will look when applied on to the painting.

Simple Palette Suggestion for Portrait Painting

The following colours need to be hand-ground and laid out in the following sequence:

Lead white+yellow ochre; lead white+vine black (make a very pale grey, almost white); lead white+vermilion (make 3 tints of varying strength); pure vermilion; yellow ochre+vine black+lead white; yellow ochre+vine black; burnt sienna; vine black; vermilion+vine black+lead white (make 2 tints); vine black+lead white (mid grey); lead white+naples yellow (very pale yellow).

This palette accords to late 18th-century portrait palettes of the English school.

Simple Palette Suggestion for Landscape Painting

Lead white (set to one side, for making admixtures and half-tints); zinc white (set to one side, for making admixtures and half-tints, especially with transparent colours); viridian; yellow ochre; orange ochre; raw sienna; indian red; burnt sienna; ivory black; ultramarine blue; cobalt blue; cadmium yellow.

This palette accords to late 19th-century French landscape palettes.

Oil Paint Mediums

The use of oil painting mediums is crucial to the realisation of the image by the artist. The simplest way to modify a paint film is to dilute it with a solvent such as turpentine. This will allow the paint to brush out freely and create more transparency within the paint film. However, dilutions of oil paint that rely on solvent alone tend to leave the dried paint film less glossy and, in the worst cases, underbound. Over dilution of paint with solvent can cause the paint film to break down and become too matt, underbound and liable to "chalk" if rubbed, ultimately leading to loss of the paint film in the most extreme circumstances.

The key reason to add oil paint medium to oil colour, is to retain the inherent sheen of oil colour when diluting or thinning the paint so that it can be spread out over a large area, for example, when glazing.

Manufactured oil colours are formulated to give a specific finish when applied undiluted. The exact appearance of the dried paint film will differ from one manufacturer to another. Some oil paints are made to be oil-rich, others have a more matt finish. It may therefore be advisable to incorporate a paint medium into the painting process, to modify the final appearance of the applied paint film.

In general, paint mediums are employed to maintain the original finish of the paint film, or to change the appearance of the paint film. The most common desire among artists is to achieve a high gloss finish, regardless of the dilution of the paint. In such cases, a small addition of a glossy paint medium (e.g. dammar varnish with stand oil), perhaps 10% to the amount of oil paint present, is sufficient. This creates a glossy sheen when applied undiluted, but retains gloss, even when the mixture of oil paint plus medium is subsequently diluted with a solvent. In practice, the oil paint medium retains a glossy structure, regardless of dilution. In this manner, a relatively thick formulation of the oil paint medium can be added in small amounts to the oil colour, then subsequently diluted with a solvent to the thickness/thinness required.

Problems with paint mediums tend to arise when too much medium is added – so the inclusion of paint medium is best done in moderation. If for example, 50% paint medium is added to oil colour, then the resultant paint film has less to do with oil paint than with the properties of the medium used.

Oil paint mediums can be composed of fusions of drying vegetable oils with dissolved tree resins, but may also be derived from synthetic resins, such as alkyd resin. It would be useful to understand the relative properties of these raw materials before opting to use mediums based on them.

Oils and Modified Oils

Modern Stand Oil

A relatively non-yellowing form of linseed oil. Stand oil is linseed oil that has been thickened by heating in a vacuum. This process causes partial polymerisation of the oil, which in turn means that it does not yellow (darken) to the same extent as regular cold-pressed or refined linseed oil. For this reason it can be used as an addition to oil colours, without causing excessive darkening within the oil paint film. Stand oil is also self-levelling (does not show brush marks) and highly elastic when compared to regular linseed oils.

Sun-Thickened Linseed Oil

By exposure to air and strong sunlight, linseed oil can be thickened to produce a highly viscous form of oil, similar in consistency to modern stand oil. Sun-thickened linseed oil is self-levelling (does not show brush marks), very glossy and does not yellow (darken) with age when compared to regular linseed oil.

Sun-Bleached Linseed Oil (Historic Stand Oil)

Oil that is left to “stand” in strong sunlight for 3-4 weeks (without exposure to air) takes on a pale colour, which does not yellow (darken) with age when compared to regular linseed oil.

Cold-Pressed Linseed Oil

Reduces the effect of brush marks (self-levelling) when added to oil colours, but has a strong golden yellow colour, which may be noticeable when used with pale colours and whites.

Refined Linseed Oil

When added to regular oil colour, refined linseed oil will darken progressively over time and also show brushmarks.

Alkyd Resin

When acid and alcohol are combined to create an ester, a material known as alkyd resin is formed. In order to create a paint binder, this ester is modified with an addition of soya bean oil, (or other vegetable drying oils), to impart flexibility. The ratio of ester to oil may be in the region 40:60, but this will vary according to the type of product and its end use. Alkyd resins dry through oxidisation, in a process similar to that of drying vegetable oils such as linseed oil. However, with alkyd resin, the drying time is usually shorter, owing to the particular film-forming properties of the resin. Additions of drying agent may also be incorporated into alkyd resin binders, to give very quick drying properties.

Alkyd resins are widely employed in the manufacture of industrial and decorating paints, where their thixotropic properties and fast drying characteristics are exploited. Alkyd-based paints were introduced during the 1950s and today almost completely replace oil as the chief binder in industrial and decorating paints. Some manufacturers of artists' colours offer lines of paint using alkyd resin as a binder. These paints tend to dry quickly and as such have been successfully used for quick-drying underpainting. Care must be taken in such applications that the alkyd paint is thinned a little with solvent so that the dried paint film is slightly matt (i.e. if undiluted, the dried glossy paint film may offer a poor surface for subsequent layers of oil colour to adhere to). Some special colours, such as the pearlescent pigments and metal-based pigments may be presented in paint ranges as being milled in alkyd resin. Such formulations help to provide a more stable paint consistency, although they will tend to dry much more quickly (perhaps in only a few hours) than regular oil-based paints. Industrial or decorating alkyd paints often include a large amount of filler material which tends to make the dried paint film rather brittle, especially after prolonged drying (six months or more). As a consequence, industrial grades of alkyd resin and alkyd paints may not be suitable for working on to flexible supports. Similarly, these paints may not perform well over time on to rigid supports, although it tends to be the case that industrial/decorating alkyd paints may show defects in terms of colour (i.e. the pigments used are not lightfast), rather than deterioration of the paint film. Some alkyd paints, which are formulated for use on ships, may be used on metal panels, such as honeycomb aluminium panel. Reassurances in relation to pigment content may be advisable in the case of such applications. It may be preferable to prepare dry pigment into an appropriate alkyd resin binder when working on to metal panel supports, where the permanence of the chosen pigment can be determined by the artist.

Alkyd resins have a warm yellow-orange colour. They can be formulated to create a flowing, self-levelling paint film when added to oil colours. In most manufactured paint mediums, alkyd resin has been treated with a drying agent, so that each paint film mixed with it will dry within a few hours, allowing multiple coats to be applied quickly. The colour of alkyd resin may progressively darken, especially with pale colours and whites, and especially if too much alkyd resin (i.e. more than 10-15%) is added to oil colour. Alkyd resins are presented in the form of free-flowing liquids, syrup consistency and also as gels. They share a property referred to as being "thixotropic": this refers to the fact that the alkyd is static before manipulation. Once the alkyd resin is agitated with a brush or painting knife, the resin begins to flow, enabling it to be spread out over a wide area easily. Alkyd resins can be reduced in consistency by the addition of a solvent (e.g. turpentine, white spirit, odourless thinner) to create thinner, finer films. Alkyd resins remain flexible when applied as thinish films but may become more inflexible when applied thickly. Those formulated as a gel are intended to be mixed with the desired quantity of oil colour and then applied flat to form a thinner, even paint film. If the alkyd is applied as an impasto gel, it will dry with a degree of wrinkling or shrivelling. In practice, it dries quickly on the surface but remains squidgy underneath and is therefore unstable. Alkyd gels applied in this fashion may also remain temperature sensitive. For example, thick alkyd gels appear to regain some stickiness in extremely hot weather.

Some manufacturers offer alkyd gels that have an inclusion of silica. This helps to maintain the structure of the gel, effectively allowing it to be applied with some impasto (perhaps 5-10mm thickness) without undue shrinkage or shrivelling upon drying. Similarly, some manufacturers suggest using additions of synthetic wax (microcrystalline wax) to help maintain impasto. It is advised to refer to individual manufacturers' recommendations in this respect.

Waxes

Beeswax

The most flexible of all the natural waxes, beeswax is offered in two forms:

- raw beeswax, yellow beeswax
- refined beeswax, bleached beeswax

The refined product has been cleaned and has a white colour. It is normally supplied in small pellets which are easy to melt, or dissolve in solvent. Over time, the pale colour of refined beeswax reverts back to yellow. The raw, yellow beeswax is slightly more flexible than the refined product, but the dark yellow colour may compromise mixtures involving pale colours and white. Yellow beeswax is also supplied in small pellet form or in the form of larger, raw lumps.

Beeswax is easily dissolved to a soft paste by leaving to steep in rectified turpentine as follows:

Beeswax pellets	1 part
Rectified turpentine	3 parts

Leave in an air-tight container for 3-4 days, stir occasionally until free from lumps, forming a soft gel paste, similar in consistency to Vaseline. Alternatively, beeswax can be melted under heat, then while still warm, added into oil paint mediums (see recipes).

Beeswax will darken over time. It remains temperature sensitive, indefinitely. If too much beeswax is added to oil colour, the whole paint film will take on this characteristic. As with all paint medium additives, wax is added sparingly.

Carnauba Wax

This plant wax is often used in paint mediums to create hardness within a paint film. Carnauba wax is offered in natural (grey colour) or refined (yellow) form. It is normally melted then added in very small quantities (perhaps 5%) to paint mediums that already contain a beeswax element. This small addition is enough to impart toughness to the dried paint film. The dried film may also be buffed with a soft cloth to a polish. It is not flexible enough to use on to stretched canvas but forms a tough, durable film on to panels. Fusions of beeswax with carnauba wax are used when making oil paint in stick form. Usually such sticks also include stand oil as the binding agent. This formulation gives a thick, waxy stick of colour, which can be freely applied to any suitable oil painting support but especially to rigid supports which provide a degree of physical support to the applied stroke of oil stick.

Synthetic Wax

Microcrystalline waxes tend to be more brittle than natural waxes, despite their pale colour. They are dissolved in white spirit/odourless thinner, in a similar fashion to natural beeswax. Small additions of this wax may be possible when oil painting on to rigid supports, although it is far too brittle for use with stretched canvas.

Other synthetic waxes, such as paraffin wax are even less desirable because they are even more brittle and possess a very low melt point.

Natural Resins

Many types of tree, especially coniferous ones yield sticky resinous liquids that, when hardened form into “resin” material. When such resins are immersed into the appropriate solvent, they form solutions, which provide glassy, transparent films and are commonly employed as varnishes, or as the varnish component of a paint medium. In truth, many recipes for varnishes and painting mediums are based on fusions of different resins, in association with drying vegetable oils. The reliability and appropriate use of such varnishes and painting mediums has been called into question, especially in the last 30-40 years. However, there is still a demand from artists to use traditional recipes for varnishes and painting mediums and for this reason, it is worth considering the working properties and characteristics of historically important resins and other raw materials which have been used in oil paint technique.

Resins are often used to impart glossiness to paint films: by careful dilution and admixture with oils, etc, the exact gloss and depth of the paint film coating can be adjusted as required. In general terms, wherever a resin is employed in a paint medium recipe, its relative brittleness (lack of flexibility) is countered by the addition of a quantity of drying vegetable oil, such as linseed stand oil. This fusion between resin and oil affords the combined product with a degree of flexibility and a change in the gloss/colour saturation of the final paint film. Resins, dissolved in the appropriate solvent alone, when added to oil paint, would tend to give rather brittle paint films.

In the case of oil painting, most of these resins are employed after they have been solved into turpentine and mixed with vegetable oils, so that they form oil resin mediums. By contrast, some of the resins may be dissolved into alcohol. These alcohol-based varnishes (or "spirit varnishes") cannot be admixed with oil paints, because the alcohol prevents dilution/admixture with oil-based material. In historical paint technique, sometimes alcohol-based varnishes have been used as isolating coats between layers of oil-based paint. Such coats form a barrier between oil paint layers. Alcohol will not disturb oil paint layers, nor will oil paint layers applied on to dried alcohol-based varnish disturb the varnish layer. The turpentine used to dilute oil paint films will not redissolve dried alcohol-based varnishes. In theory, this sounds like an excellent system of isolating one area of dried oil paint from another. In practice, alcohol-based varnishes tend to be very brittle and prone to cracking (e.g. sandarac, shellac). As a consequence, they form a weak link in the structure of the painting and should be avoided.

Dammar

Dammar is one of the softest tree resins used in paint media. It has a pale, almost white colour, is sold in small lumps and is usually dusty on the surface but breaks to reveal a translucent core. Dammar dissolves wholly in turpentine to form a pale, star-coloured varnish. In this form it can be mixed, without any heat, with drying vegetable oils and is especially suited to admixture with stand oil, where it forms an excellent, glossy and relatively flexible paint medium.

Mastic

Tree resin from Chios, a Greek island (but also from other sources in Greece and North Africa) derived from a species of pistaccio. The bark is incised in springtime and the resultant sap collects into tiny beads and then hardens. These characteristic hardened "tears" of pale yellow mastic resin are then harvested in late summer. Mastic readily dissolves into alcohol. With turpentine and spike lavender oil the resin dissolves readily when placed in a warm water bath at the beginning of the solving process. Subsequent stirring is also advised to give a quick-forming resin solution. Mastic is a soft resin with some elasticity. While in solution and mixed with other resins, it aids the adhesion of other resins to the support.

Mastic has been employed in many historical paint mediums, usually cooked with a drying oil. For example, the dry resin is heated until molten; warmed linseed oil is then added to the molten resin and the two are combined over heat to form a unified mixture. The end result is a thick syrup, slightly cloudy and golden yellow in appearance. When a small amount of this concoction is added to oil paint (about 10% medium to paint), the resultant paint film is glossy and enamel-like. In some cases, a drying agent would be added to the oil, to increase the speed of drying. This drying agent may have been based on a metal salt, such as cobalt siccative or manganese drier, or could be the result of having steeped a lead-rich pigment in the oil. For example, if massicot (lead mono-oxide) is left to steep, covered with linseed oil, for a period of 2-3 weeks, it imparts a drying action into the oil. The liquid oil is filtered from the pigment and only the clear oil is used in the manufacture of the paint medium. Because such mixtures involve the use of toxic, lead-based raw materials, they have all but disappeared from paint material catalogues as prepared mediums. However, the raw materials are still offered by some specialist companies and as such, it is important to mention their existence.

Sandarac

Derived from the sap of a variety of pine found in North Africa, especially Morocco, sandarac is a pale, straw coloured resin, formed in the shape of long droplets. The sap is harvested from the tree bark by incision, the hardened droplets are later gathered. The resin fractures easily and usually has a slightly dusty, grainy powder surface. Sandarac can be solved into alcohol completely to make a spirit (alcohol) varnish which is softer (less friable) than shellac. Such alcohol-based varnishes have been employed in oil painting as isolating coats between layers of oil paint.

It can also be partially solved into warm turpentine (the residue must be filtered) but will dissolve completely into spike lavender oil, allowing it to be used with various drying vegetable oils. Whenever spike lavender oil has been used in oil paint media, take great care! Spike lavender oil has a solvent action when applied on to dried oil paint: it may act like a paint stripper, dislodging previous layers, percolating into them and making them soft or sticky. As a consequence, the use of spike lavender oil (and lavender oil) is perhaps less than wise. It may be admissible in a final paint layer, where the previous layers have completely dried. Sandarac was used in the past as a final varnish coating, because it has a slightly paler, clearer finish than shellac. Its relative inflexibility makes it more suitable as a varnish coating for rigid supports than flexible ones. It may be used as a final varnish for tempera, where it will deepen and saturate colour values, without causing excessive darkening or yellowing of the finished paint film appearance.

By contrast to mastic, sandarac is slightly harder (more brittle) as a varnish coating.

Colophony

Where pine trees are used for turpentine production, colophony is the term used to describe the solid residue left behind when turpentine is distilled. This resin has a very high acid content and is extremely brittle. When incorporated into oil paint mediums or varnishes, it tends to lead to cracking or splintering. As a consequence it is advised not to use colophony at all for permanent oil paint techniques. Colophony dissolves readily into turpentine but also with alcohol.

Copal

A family of tree resins derived from fossilised, or partially fossilised plant material. Copals are hard and give glossy coatings. “Congo Copal” is the most highly desired of this resin group, dug from fossilised trees, typically lying beneath swamps. The difficulties of extraction, coupled with the fact that such resins are no longer required by industry (where modern alkyd resins are now used) mean that fossilised copal resins are now hard to find on the market. In order to put copal into solution, it is first “run”, by heating until it melts and forms a solution. This hot bath of resin can be fused with linseed oil, or other drying oils, to make a thick syrup. The mixture can be diluted with turpentine to the desired consistency.

Copal oil mediums, based on a heated fusion of congo copal resin with linseed oil, were previously used in oil paint technique, to give a very glossy, enamel-like finish to paint films. When a small amount, perhaps 10% is added to oil paint, the resultant mixture is shiny and transparent. Such mixtures were employed to a great extent during the 19th century, especially in England. The defect of copal in oil paint mediums is that it forms a hard but brittle film. It also darkens excessively, changing pale colours to an orange-brown glow over time. Some paint manufacturers continue to offer copal-based mediums, despite these known drawbacks. Such mediums may typically be fusions of copal with thickened linseed oil (modern stand oil), in the form of a thickish syrup, which can be thinned with turpentine as required, or even a gel formula “Megilp”.

Other forms of copal are often mentioned but are not suitable in oil paint technique: "Kauri Copal" is a partially fossilised resin from New Zealand, which is soluble in alcohol only; "Manila Copal", confusingly, is not from fossilised resin. It derives from a type of conifer native to Manila and actually imparts a softish varnish film when solved into alcohol to make a spirit varnish.

Amber

Another type of fossil resin, amber is collected from open pits or from shore deposits in the Baltic States, where it is often washed up along the coastline. Amber is a solid resin, and extremely hard and glassy. As a consequence, it is very difficult to form into a solution. It melts at 290°C and in this state can be solved into linseed oil to form a permanent liquid varnish. Because of the very high temperature involved, the utensils used in manufacture are likely to be unusable afterwards, being caked in hard, cooled resin. The vapours given off are rather noxious and the burning of amber should always be done out of doors and using appropriate protective equipment. Spike lavender oil is sometimes added to the linseed oil to help keep the resin liquid but this leads to a coating with a longer drying (curing) time. Artists have found amber-oil mediums useful in terms of their extreme gloss and enamel-like finish. Mediums based on fusions of amber with linseed oil or walnut oil may be useful for the laying down of multiple glazes, without pick-up from one layer to another. Such amber-oil mediums shift from wet to tacky rapidly, allowing subsequent coatings to be applied while still tacky but no longer in a fluid, liquid state.

In recent years, there has been a revival of interest in amber as an oil painting medium and some specialist companies have begun to offer various formulations based on amber to the market. However, in practical terms, their high cost precludes their use for most artists.

Gum Elemi

Elemi, the best types of which are procured from Manila, is collected as a soft-resinous mass, containing many impurities. If left exposed to air, it hardens and is then unusable. It can be dissolved into warm turpentine to form a solution, which is then strained to gain a straw coloured (but slightly cloudy) liquid. Elemi is very soft and can be incorporated into oil paint medium recipes as a plasticiser. However, over-use may provide films that are rather sticky and possess a certain cloudiness.

Tree Balsams

A number of trees yield sap residues which are collected in this form and kept as thick, viscous liquids. These tree balsams, or “oleo-resins” are highly prized for their clear films and brilliant sheen. When warmed slightly, they flow better than in the cool state. They are sometimes added in small proportions (e.g. 5-10%) to other oil paint mediums to increase the gloss and brilliance of the final paint film.

Venice Turpentine

From the European Larch, this tree balsam (it is collected as a liquid sap and used as such) is often used as an additive to varnishes to impart flexibility and extra gloss. Good varieties do not discolour because they do not contain abietic acid (as is the case with colophony and some other pine resins, which take on a dark yellow-orange colour that can become progressively darker with age). As a consequence, venice turpentine is highly prized by oil painters (especially so in the golden period of Venetian painting, hence the name of the material). The best quality of venice turpentine is collected from larch trees in the Austrian Tyrol. The best sap is located at the heart of the tree and this is collected by drilling into the tree’s centre. This perhaps explains the high cost of the material. Small amounts of venice turpentine are added to other ingredients to impart luminosity and brilliance, to gain an enamel-like surface. It may also be used to impart flexibility to harder resins. Modern venice turpentine tends to be very thick in consistency and has to be placed in a warm water bath to gain fluidity, from which point it can be diluted with a little turpentine to provide a permanently fluid formulation. In earlier times, venice turpentine was probably less viscous and easier to brush out without warming. Sometimes this material is sold under the name "Venetian Turpentine". This can be the same material, but more commonly, it infers that the true venice turpentine has been adulterated with colophony, thereby giving a more brittle film upon drying.

Strasbourg "Silver-Fir" Turpentine

Often mentioned in historic texts, the so-called "Silver-Fir" or "Strasbourg Turpentine" is similar to venice turpentine but has a paler colour. It is sourced from silver-fir trees in the Vosges region of France but also, and perhaps more importantly, it has been derived from silver-fir trees in the Italian Tyrol, often mentioned in old texts as "*olio d'Abezzo*". The balsam is collected from openings in the bark caused by natural blistering. It is used in a similar way to venice turpentine and is particularly useful for coating pigments that are susceptible to degrading when exposed to atmospheric conditions: the balsam envelopes the pigment, thereby offering protection.

Copaiva Balsam

Derived from Latin America, this balsam contains volatile (essential) oils which can have a solvent effect. The balsam has a red-brown colour and dries to form a glossy finish. However, the essential oils remain active in the varnish/paint film and can cause previous layers to dissolve or pick-up when brushing. Similarly, top coats will be affected by the undercoat. As a consequence, it is used with some caution.

Canada Balsam

Found in Europe from the 18th century onwards, canada balsam is from a species of pine tree native to northeastern North America. The bark of the tree yields a very pale balsam, not unlike strasbourg turpentine but slightly paler. The balsam only occurs where the bark has blistered: as a consequence, collection of the material is protracted and difficult, lending this material a high price in the market. It is used in a similar way to venice and strasbourg turpentine.

Sample Recipes for Oil Painting Mediums

There are a selection of "standard" recipes for painting mediums. Variations on these and many other recipes are possible. The following recipes can be seen as a starting point for further experimentation and exploration.

GLAZE MEDIUM (Resin-Oil Medium)

To improve the brilliance of oil colour and to help avoid oil colour sinking, a simple glaze medium can be introduced. This medium will help extend transparent colours without their losing adhesion or luminosity.

Recipe for Glaze Medium

Dammar varnish (1 part dammar resin to 3 parts turpentine, see Varnish Recipes)	50ml
Linseed stand oil	50ml
Double rectified turpentine	200ml

The varnish and oil are stirred together, before adding turpentine. Stir each time used. Less turpentine will give a more viscid medium. This glaze medium is flexible and keeps for a long time in a sealed bottle.

Scumbling

The glaze medium can also be used for scumbling of oil colour. The amount of turpentine is reduced, so that the medium is thicker and more importantly, slower in consistency. This more viscid medium is mixed with colour on the palette and then scumbled with brushes, rags, fingers or painting knives across the painting surface. The effect is to slow down the flow of oil paint, effectively dragging the colour. A combination of glazes and scumbles can be built up to form a unifying whole: such applications can be re-worked while still wet, scraped off, or worked over with fatter paint mixtures. Always, when applying mediums, scumbles and glazes refer to the Fat over Lean principle. Fatter layers always sit on top.

Impasto Mediums

Oil paint has a bad tendency to wrinkle and dry in on itself when applied neatly (without additions) in thick impasto. This is particularly the case with glazing colours such as alizarin crimson, which takes such a long time to dry when applied thickly, that the surface dries out first and shows wrinkling. Extenders such as blanc fix could be introduced but this would change the colour and also make the paint rather underbound and heavy. Better practice is to introduce a wax-based medium. Beeswax is the most flexible of waxes and combines well with the drying oils and with oil paint. It is dissolved to a soft paste with turpentine. When adding wax to oil paint never add more than about 5%. Beeswax tends to cause adhesion problems, there is also the possible risk of the paint film remaining soluble in white spirit or turpentine. Beeswax paste alone would be too soft and attract dust and dirt to the picture surface. Beeswax remains vulnerable to the solvent action of turpentine or white spirit. To overcome this and to impart more flexibility, oil can be added to the wax paste.

Beeswax Medium

Beeswax, natural yellow (refined bleached beeswax turns yellow with age, so is no advantage)	100g
Linseed stand oil	75ml
Double rectified turpentine	300ml

Method 1
1. Place beeswax in a saucepan.
2. Melt beeswax on low heat. Take off heat, pour oil into liquid wax, stir. Place back on heat until clarified.
3. Remove from heat, add turpentine. Leave to cool, to form a paste.

Method 2
1. Place 100g beeswax in pan. Cover with 300ml turpentine.
2. Leave to soak for 2-3 days until dissolved.
3. Stir oil into soft beeswax paste. Place in a warm water bath if necessary, to gain homogeneous mixture.

Carnauba, a plant wax, can be added to beeswax mediums to impart hardness but only when applied to rigid supports.

Resin-Oil-Wax Medium

Wax-based oil mediums can give a less matt finish by admixing with resin-oil.

Beeswax	100g
Linseed stand oil	50ml
Turpentine	300ml
Dammar varnish (100g resin to 300ml turpentine)	50ml

1. Dissolve the beeswax in turpentine and add oil (as per beeswax medium).
2. Stir in dammar varnish, with container placed in warm water bath.

Imparts lustre and a tougher sheen to beeswax medium. Add more turpentine if too thick, or to reduce to a softer gel consistency.

Manufactured Paint Mediums

Variations upon the mediums described are sold through the art materials trade. Preparation of painting mediums from the raw materials is advised simply so that the artist gains control over the ingredients employed. Manufactured mediums are never universal or standard, each make of “glaze medium” may contain a great variety of ingredients, the properties of which should be understood before incorporating into paintings. Manufacturers’ technical notes in catalogues and brochures give advice on the contents and uses for specific painting mediums.

Alkyd resin based oil paint mediums have been widely used by manufacturers. Alkyd is a synthetic resin that has been oil-modified and is compatible with oil colours. It is often prepared with a siccative to give fast drying and comes in a variety of consistencies, from a liquid, soft gel, jelly, to a rubbery gel. The thicker varieties are often used by artists to create thick impasto passages of paint. These thick gels tend to dry in on themselves when applied very thickly. It is probably better practice to use alkyd mediums in flat glazes only, where the medium is levelled out and dries at an even rate. Too great an addition of oil paint medium may impair the adhesion of paint layers.

Other prepared painting mediums include fast drying, fluid mediums. These contain drying agents but are preferable to the addition of neat siccative such as cobalt drier to oil paint, as the prepared drying medium is (hopefully) always made to the same recipe. An artist adding neat drier has always the potential to add too much to the paint mixture, causing bad cracking of the paint film.

Picture Varnishes

Final varnish for oil painting is applied when the painting is absolutely dry. The drying process takes from one year to one hundred years, or even longer, depending on the thickness of the paint, its constituent parts (e.g. added mediums) and the conditions in which it has dried. Varnishing a painting before it is properly dried out leads to cracking of the varnish film and the possibility that the varnish is absorbed into the drying paint film, leaving an uneven final varnish film on the surface. Varnish is applied to protect the painting from atmospheric pollution, dirt, smoke, humidity and dust. The varnish film can become stained by these elements. Restorers prefer a varnish that is removable, so that before it becomes dirty, or cracks, it can be replaced.

The ideal varnish would be removable (i.e. able to be re-dissolved with solvents by a trained picture restorer), non-yellowing, non-cracking and flexible. No picture varnish on the market completely fulfils these expectations. The natural resin varnishes, mastic and dammar are often used for varnishes. Mastic gives a very fine varnish when dissolved in turpentine, although it yellows appreciably and is prone to embrittlement and blooming. Dammar yellows to a lesser degree but is more friable and gives a softer finish. Previously, varnishes based on copals (very hard resin) and colophony were used as picture varnishes. However, such resins produced hard, glossy films, that were very prone to darkening and in the case of colophony, cracking and embrittlement.

Synthetic resin picture varnishes, such as "ketone N" are often preferred to natural resin varnishes. Ketone is thought to yellow very little but may become brittle and difficult to remove with age. New varnishes, based on acrylic resins, are available and these may become more important in the future as final picture varnishes.

Varnishes can be tinted with pigment to achieve certain effects as desired. The addition of oil colour to a varnish mixture renders it less re-soluble. A better approach may be not to varnish at all but to work in a resin-oil technique, building up coloured glazes and scumbles as previously described, so that all layers of the painting and especially the final layers are effectively bound and protected from atmospheric pollution and have a reasonable lustre. Paintings under glass (glazed) are better protected from the atmosphere, dirt and dust.

Varnish Recipes

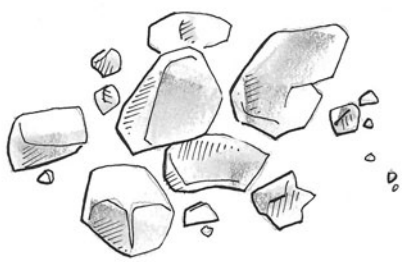
Dammar Varnish

Dammar resin	100g
Double rectified turpentine	300ml

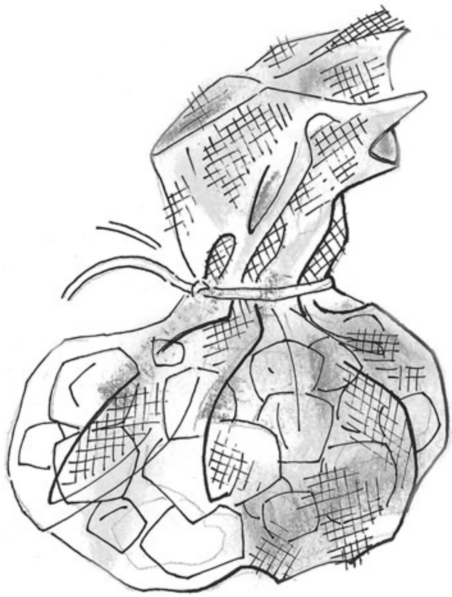
Place the resin in an improvised bag made from muslin (or old tights), and tie the top with string. Immerse the bag in the turpentine and leave (covered) for 2-3 days to dissolve.

The resultant varnish can then be used as a painting medium ingredient (see recipes), or thinned further with turpentine, to make a varnish. Final picture varnish should be thin enough not to change the appearance of the painting too much. Dammar varnish that is too thick will remain sticky and soft on the picture surface.

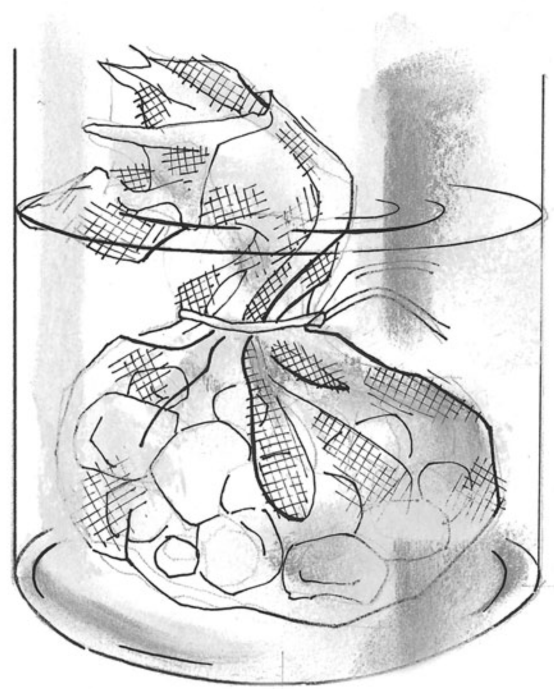
Procedure for Making Dammar Varnish



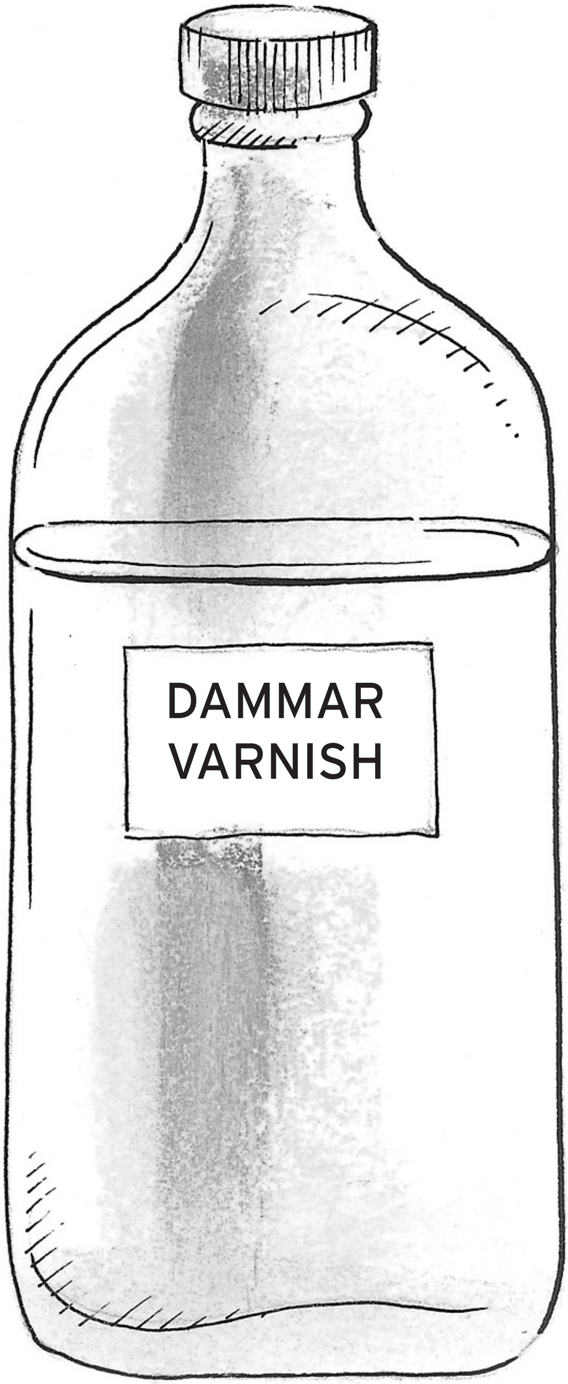
Lumps of dammar resin



Dammar resin wrapped in muslin bag



Dammar resin is suspended in rectified/distilled turpentine



The resultant varnish is filtered through muslin then bottled

Mastic Varnish

Mastic resin	100g
Double rectified turpentin	300ml

Dissolve as per dammar varnish. Mastic can be used to achieve a very fine picture varnish by dilution with turpentine.

Mastic varnish should be prepared in dry conditions, without humidity or damp cold air, which could induce "blooming" into the varnish/paint film. This manifests itself as a slight clouding in the dried varnish film which cannot be removed. As a consequence, varnish making in Northern Europe is best done on warm spring and summer days.

Matt Dammar Varnish

Dammar varnish	100g
Beeswax	25g
Double rectified turpentine	300ml

Dissolve the beeswax to a soft paste in a proportion of the turpentine, then add to the rest of the varnish. The wax should be warmed (place bottle/can in warm water bath) before pouring into the varnish. When cooled, the wax tends to collect at the bottom of the mixture: heat in warm water bath before each application. This varnish imparts a satin-matt finish (slightly cloudy effect) to the picture surface, softening colour relationships.

Ketone N Resin Picture Varnish

Ketone N resin	100g
Double rectified turpentine, or white (mineral) spirit	300ml

Dissolve as per dammar varnish. The can containing the mixture is placed in a warm water bath to aid the beginning of the dissolving process. The mixture is stirred/agitated from time to time while dissolving. Produces a water white, non-yellowing picture varnish.

Solvents for Oil Painting

When used to thin oil colour, the solvent should ideally evaporate cleanly without leaving a residue. Take care when handling oil paint solvents. Prepare hands with a good quality barrier cream before working and wash thoroughly with soap and water if in contact with solvent. Ensure good ventilation in the studio when working with solvents.

Turpentine

Turpentine, distilled from pine is of great value to the artist as a solvent for oil colours but also as an essential ingredient in painting mediums and varnishes. Turpentine has a sweet aromatic smell. The best grade is that which has been double rectified. This means that the gummy residue contained in pure gum turpentine has been removed. This residue converts into a sticky mass when exposed to light, making it unsuitable for painting purposes. As a consequence, double rectified turpentine is preferred, as it is free of this gummy deposit. Turpentine should be kept in closed metal cans or brown bottles, away from sunlight, to avoid discoloration and thickening. Turpentine thickens when in contact with air: keep stored with the cap tight. Always use as fresh a supply of turpentine as it is possible to obtain.

Turpentine evaporates from paint mixtures at an even rate, reducing the chances of colour sinking unevenly when thinned out. It has a more oily presence than mineral (white) spirit. Turpentine is preferred when dissolving resins such as dammar, when making varnishes and oil painting mediums. It has a stronger solvent action than white spirit.

White (Mineral) Spirit

A petroleum solvent, distilled directly from coal. It has a drier presence and evaporates more rapidly and more unevenly than turpentine. It is much cheaper than turpentine and can be used for brush and palette cleaning. White spirit is made more stable as a painting thinner by admixing with a small amount of stand oil. This should be done fresh for each painting session: the oil helps the spirit settle out more evenly. Low odour mineral spirit (OMS) is also available and may be preferred by many artists.

Low Odour Thinner/Odourless Mineral Spirit

A low odour solvent, where the proportion of aromatic hydrocarbons present has been significantly reduced. Shellsol T is a typical example of a low odour thinner. It evaporates at a similar rate to turpentine, leaving oil paint with an even finish. Shellsol T and other OMS – odourless mineral spirits - tend to evaporate over a period of a number of hours. Typically, the release of solvent vapour takes place towards the end of the evaporation period (for example after perhaps 6-8 hours from application).

Gum Turpentine

This type of non-rectified turpentine contains a gummy residue, which can interfere with paint mixtures. It also becomes more sticky and yellows when exposed to light and heat. The gummy residue is related to colophony, or rosin, which is the by-product of turpentine production. Colophony in solution forms a very brittle, unstable film and should be avoided at all costs unless the artist desires a brittle, cracking paint film.

Over-thinning of oil colour may cause paint to lose adhesion. A characteristic of this is when the paint breaks up into tiny rivulets, leaving behind underbound islets of pigment.

Clean-Up of Oil Paint, Palette and Brushes

Painters are prone to bad studio practice: the image is everything and a tidy workplace is far from the mind while working. However, a few simple procedures can be followed to make cleaning-up easier and the studio a more pleasant place to be.

The most important step is to make sure your working space is clean and obstacle-free before starting. When painting we often forget where we are, so lessen the chances of accidental spillage etc, by spending a few minutes before starting work, reorganising the studio using common sense. Have a good supply of clean-up materials to hand in case of spillage.

Painters often douse brushes in mineral spirit/double-rectified turpentine/OMS to loosen oil paint from the bristles. This process inevitably dries out the brush hair and makes it brittle. Try immersing brushes in mineral (Vaseline) oil to free oil paint from bristles, then wipe on to a soft rag. You could also try cheap sunflower/vegetable oil from the supermarket. The process of immersing brush tips into these oils helps loosen the oil colour, so that it can be largely removed from the brush hairs by gentle rubbing on to a soft rag.

To cleanse brush hairs thoroughly, use olive oil soap, supplied in grated flakes. Take a handful of soap flakes and put into an empty, clean food container. Pour boiled water from a kettle over the flakes and leave for 10-15 minutes, stirring every now and then to gain a smooth gel consistency. The resultant gloopy gel of soap can be used to clean oil colour completely from brush hairs. The soap naturally restores oil back into the brush hairs, so helping to prolong the life of the brush. Once all oil colour residue has been freed from the brush hair, rinse under warm water to rid the brush hair of any soap residue. Leave the brushes to dry overnight before re-using. If you can, hang the brush so that the hair points down (i.e. handle at top), so that any remaining water/paint residue follows gravity, rather than collecting in the ferrule of the brush (the commonest cause of split hairs with brushes!).

When working with oil colours/dry pigments/solvents, always try and wear protective gloves, so that skin does not come into contact with potentially harmful materials. If you treat all pigments as being potentially harmful, it will quickly become standard practice to treat all the materials you use with respect.

Solvent Disposal and Dispensation

Solvents used in the studio require dispensing from one source. Ideally, this is a lockable cabinet. Individual solvent dispensing units (plunger cans) are also available.

It makes very good sense to limit the types of solvent used in the studio to one. The most suitable solvent currently available is odourless mineral spirit (OMS).

Never throw solvents down sinks or discard them carelessly. Try and be as sparing as possible with solvents: if you use them to dilute oil colour, only decant what you need for each painting session. Preferably use a prepared paint medium to dilute paint mixtures. Mediums take longer for the solvent content to evaporate, so the vapours are less pronounced while working.

If you have waste solvent, pour it into a container filled with fuller's earth (rottenstone), or fine cat litter, which is very absorbent. When the solvent has evaporated after 2-3 days, the residual powder can be disposed of safely.

Waste rags also need to be carefully disposed of. Ideally, the studio will have an oil waste can (with a closing lid). This prevents rags, soaked with linseed oil from causing fires through self-combustion.

Watercolour and Gouache Painting

WATERCOLOUR

Historical Background

The origins of watercolour spring from the cake colours of the Chinese and Japanese. These were compressed cakes of colour, which re-dissolved with water. The binder for these paints was often fish or animal glue size. Such paints were widely employed on fine textiles, such as silk, as well as paper made from bark or rice. The closest likeness to this paint available today are the compressed Chinese inks, which give out colour when rubbed against an ink stone in the presence of water. In Japan, watercolour paints are still available based on pigments bound in deer skin glue.

In medieval Europe, water-based paints, bound with resoluble gum, glair (egg white) or animal size were used for painting illuminated manuscripts. Albrecht Durer (1471-1528) was one of the earliest artists to liberate gum tempera (i.e. aqueous gum binder + pigment in place of egg + pigment) from being a decorative medium. During the 17th century, the Dutch began to develop watercolour painting further, through landscape painting. The British championed the use of watercolour at the close of the 18th century, to record the “Grand Tour” of Europe, taking in the ancient and modern sights of Italy and the extreme landscapes of the Alps.

Initially, watercolour was used merely in the form of tints over pen line drawings. This application gradually developed to a more personal use of transparent watercolour by early pioneers such as

Thomas Girtin (1775-1802) and Frances Towne (1740-1816). Each summer Girtin made tours of Britain, making landscape studies which would be developed during the winter in the studio. He began to employ broad washes of colour, restraining the use of descriptive detail. Often this would take the form of bold washes of watercolour over monochromatic underpainting, descriptive details being touched in with fine brushes. Frances Towne made a tour of Italy in 1780-81, returning to Britain via the Alps. His Alpine studies show his technique well: striking pen and ink drawings, complemented by flat washes of harmonious colour.

While Girtin's paintings emerged from the applied notion of watercolour, the study of nature, topography and so on, his friend and rival J.M.W. Turner (1775-1851) stood such tradition on its head. Although his first works in watercolour were topographical in nature, his experience of working in oils led to the production of powerful and atmospheric landscapes, characterised by a complicated yet direct and ambitious use of both watercolour and body colour. His most lucid works were spontaneous sketches made directly in the landscape and from drawings executed on the spot. His larger exhibition watercolours were rather more flamboyant and exaggerated in style, pushing the medium to the absolute limits.

Watercolour painting became a popular pastime among the English gentry. In response, the early colour makers, Rowney and Winsor & Newton began to produce "moist" watercolours, which could be easily re-dissolved and carried in small painting boxes on sketching expeditions. Previously, watercolours had been available in compressed, hard cakes, which gave out very flat, matt, dry washes.

In the early part of the 20th century, the German Expressionist Emil Nolde (1867-1956) used watercolour in a more experimental fashion. Nolde's work is characterised by a use of bold, saturated colour. He used unmixed colour, dissolved from tube watercolour and kept in large pots. These pure colours he would then apply to highly absorbent Japanese papers (papers made with little or no sizing), so that the saturated colour would also saturate the paper.

Colourmakers today offer their watercolours in formats that will suit most approaches to watercolour painting: in a variety of sizes of sketching boxes, in the form of pans or tubes and in good capacity tubes for larger, studio-based work. Similarly, the range of supports, brushes and auxiliaries matches the demand from artists: papers for example are offered as tiny pads for outdoor work, or in the form of rolls for larger works. Artists also demand that their colours have good lightfastness and perform well. Manufacturers have begun to offer more information in this area, through their catalogues, labelling and retail outlets.

Properties of Watercolour

Watercolour painting relies upon pure pigments dispersed into a binding agent which is resoluble with water. Watercolour is unusual among painting media in that it is named after its diluting agent, water, rather than binding agent, as is the case with media such as oil paints (linseed oil) or acrylic paints (acrylic polymer emulsion).

The pigments used in watercolour are carried in an aqueous binder, usually a solution of gum arabic. The binder can be diluted heavily with water to make fine washes of thinned, transparent colour, without losing adhesion to the support. The transparent nature of watercolour allows the artist to build tonal values through layers of colour. Watercolour is a highly responsive medium, providing the artist with a direct yet delicate means of building colour, tone and form.

The main criteria for watercolour painting include:

- Fine particle size pigments
- Good transparency (although some important colours are opaque)
- Resoluble binding agent
- A matt film when dry
- Resolvability of colour on palette and on paper
- Easy "lift-off" of colour from pan or palette
- Good flow when diluted with water.

Fine Particle Size Pigments

The pigments used for watercolour painting ideally have a fine particle size, allowing for extreme dilution with water, without the paint film breaking down. Pigments with a larger particle size can break up the paint film when heavily diluted, showing a granulated effect. Traditionally, watercolour pigments are transparent when diluted with water into a wash. However, some opaque colours such as oxide of chromium green, are indispensable to the artist and are thus used in combination within the watercolour palette.

Watercolour is the most sensitive medium regarding stability to light. Because the pigments are applied in thin, transparent washes, direct sunlight can pass through the paint film, to the white of the paper support. Therefore, any fugitive pigments may be bleached out. Previously, watercolours would have been kept in portfolios and shown only under subdued light, to counter the effects of direct exposure to the UV rays in sunlight. However, the modern watercolour palette (see pigment tables in chapter on pigments) can provide the artist with a relatively stable range of colours.

Good Transparency

Traditional watercolour techniques call for pigments with a tendency towards transparency, such as the “lake” pigments. These were formerly vegetable dyes, such as madder derived from madder roots, or stil de grain yellow, derived from buckthorn berries. These natural plant dyes were then struck on to a transparent chalk base. The lake pigments tend to be rather fugitive (although natural madder survives today and is still prepared and used in watercolours by some manufacturers). In the late 19th century, organic dyes made from coal tar were introduced. This group of pigments are chemically similar to the fugitive natural dyes but possess greater tinting strength. The first coal tar dyes proved to be largely fugitive too, although some colours such as alizarin crimson are still widely used in artists' quality paints. The natural madder pigment prepared from madder root contained two dyestuffs: purpurine and alizarin. Purpurine is quite fugitive but alizarin is reasonably lightfast. Synthetically produced alizarin was introduced in 1868. Problems with lightfastness of coal tar dyes led to a meeting of artists and industry in 1908 which decided that all pigments based on coal tar dyestuffs should be at least as lightfast as alizarin crimson.

In the early part of the 20th century, superior coal tar colours such as the azo and indanthrone groups were introduced and are still in use today. Special grades of these pigments have been updated and as a result have better permanence. Later colours, derived from chemical fusions of by-products of the petro-chemical industries such as the quinacridones have even better permanence and have been readily incorporated into artists' paint ranges.

All the synthetic organic pigments used by artists are essentially colourant struck on to a transparent base, giving them similar properties to the original "lake" pigments. Their high tinting strength and good transparency provide intense, clear washes of colour, making them ideal for watercolour painting. The only drawback to these colours is their capacity to stain the paper, making lift-out of mistakes more difficult. Examples of staining watercolour pigments include phthalocyanine blue and phthalocyanine green.

Resoluble Binding Agent

The binder for watercolour is usually gum arabic, from the Acacia tree, species of which are found all over the Near and Middle East, Central Africa and India. Sudan is the principal supplier of high grade gum arabic, the best quality, from the Kordofan region is generally found in artists' watercolour and gouache paints.

The gum is collected during the dry season between October and May: the tree is "tapped" by carefully incising the bark. The tree has to reach a maturity of six years before it will yield gum. The exuded gum forms into hard, translucent irregular lumps or balls. The dried balls or droplets of gum are collected and graded according to their clarity. The paler varieties are considered most suitable for watercolour painting and should be free of impurities. Cheaper varieties are also available but these may provide a more brittle paint film and often include impurities such as bits of bark, and the pieces of gum can be a variety of shades from dark to light. Gum arabic is sold in the raw form, as lumps or balls but also in grain form (smaller pieces) and crushed as a fine powder. The gum is prepared for use as the binding agent for watercolour painting by dissolving in water (see Hand-Prepared Watercolours).

Other gums that have been used in water-based paints include cherry gum (more brittle but more glossy than gum arabic); gum tragacanth (gives a very hard, matt paint film), dextrin (starch) and methylcellulose (converted starch). Dextrin or methylcellulose are sometimes judiciously used in commercial watercolours to improve their consistency, or in the place of gum arabic, in school paints.

A Matt Film When Dry

Traditional watercolour technique demands that the paint film dries to a matt sheen. This allows the finished painting to be viewed without any glare on the painting surface and shows the true depth of tone of the pigments used.

A paint that dries to a high sheen contains too much gum. This high sheen effect may be pleasing for some artists and it is possible to add gum water to your watercolour paints to improve the gloss of the paint film. Gum arabic is sold in a prepared solution, often slightly diluted and containing preservative and plasticising agent. It can be readily diluted with water as required. Bear in mind however, that by introducing more gum solution, the paint mixture may have a more brittle film when dry.

For the finished painting to be perfectly matt, the paint employed should be as short as possible. This means that it should contain the least amount of binder to pigment possible but enough binder to facilitate dilution of the paint without losing adhesion to the support. Some brands of watercolour fulfil this requirement perfectly, while other makes will be gum-rich. The make-up of any paint has to be experienced by the artist at first hand in order to determine its suitability: some artists will prefer a rich, moist watercolour to a very short paint.

Resolvability of Colour on the Palette and on Paper

Gum arabic is a water-resoluble material. Watercolour can therefore be reconstituted when dry, both on the palette and when applied to watercolour paper. Good watercolour should be easy to re-dissolve when dry. Some brands use different formulae in their tube and pan watercolours, for example, adding more glycerine to pan colours to make them more moist. This can mean that colour squeezed from the tube is not so easy to re-constitute, once dry, when compared to pan colours.

The degree to which watercolour can be lifted out of paper when dry depends to some extent on the nature of the pigment in a specific colour. Some colours, as mentioned, have a capacity to stain the paper. Another consideration is the quality of the watercolour paper used. To assist the removal of dried washes of colour, paper should be robust enough to withstand a degree of scrubbing or rubbing with a brush loaded with water, or a wet sponge.

Easy "Lift-Off" of Colour from Pan or Palette

Watercolours are presented in pans or tubes. Pans are square (small/half pan size) or rectangular (large/whole pan) in shape. Presented in this form, the watercolour is either poured into the pan and left to set, or cut from strips of colour and pressed into the pan. There is much debate as to the relative merits of both procedures. Essentially pan watercolours should be compact yet moist compressed cakes of colour. The paint should be easy to lift off, at the touch of a wet brush. The pan should have some tack on the surface but should not be too sticky. This would signify an excess of plasticiser and/or moisturising agent.

Colour in tubes may have a different formula to that of the equivalent pan colour. When squeezed from the tube, the colour should readily dilute to make even washes.

Good Flow when Diluted with Water

Watercolour should flow readily when water is introduced, to provide even washes when brushed out on to good paper. Flow can be improved by an addition of oxgall to the painting water. This liquid, obtained from the gall bladder of the ox helps disperse washes of colour.

Stabilising agents and transparent filler can also be introduced to aid the consistency and shelf-life of commercially prepared watercolours. Such additions, along with careful use of wetting agents (oxgall or synthetic equivalents, for example, disponil) may also assist the flow of the watercolour when diluted with water.

Commercially Manufactured Watercolours

Manufactured watercolours are available in three main formats:

- 1/2 pans
- whole pans
- tubes

Generally, watercolour tubes come in small sizes – 5ml, 6ml and 7.5ml – designed to fit into travelling watercolour boxes. However, some manufacturers produce large size tubes of 15-20ml, which are more economical.

Watercolour boxes are sold complete, or as empty boxes. There is a great variety of folding watercolour boxes available for outdoor work. The best-quality boxes are enamelled to prevent rusting. Wooden studio boxes are also produced, often with elaborate mixing trays and storage compartments, which are influenced by the grandiose watercolour boxes produced in the Victorian era. Although buying the empty box and filling this up with a preferred colour range can be more expensive, it does allow the artist to select only the most necessary colours. Often this choice is based on the artist's eye and preference for certain colours.

While printed shade cards are readily available at regular art shops, always ask to see a hand-made actual colour chart. Most stores will have a copy of this chart which shows the colour neat and as a gradated wash. It is useful to prepare a similar chart of your favourite colours to keep in the studio. This can help aid identification of colours, and over a period of time will show how well the chosen colours have stood up to exposure to sunlight. It may also be useful to keep a swatch of colours in the window, with half of each colour paint-out covered and half exposed. This may show if a colour is prone to fading.

Variety in Quality and Price

"Artists' Quality" watercolours are generally sold in different price series and each manufacturer may have a different price structure. "Second Grade", or "Student Quality" watercolours tend to have one price across the range, offering the beginner a reasonable selection of colours at an affordable price.

In second grade colours the expensive cadmium and cobalt pigments tend to be replaced with mixtures, frequently using synthetic organic pigments. Often, second grade watercolours are prepared with a different binder, generally a mixture of gum arabic with dextrin (a water resoluble starch). Dextrin is used in minimum amounts as an addition to watercolour, to improve the smoothness of the paint. Excess will make the paint too dry and crumbly, providing less adhesion to the support. Cheap poster paints (which readily crack and crumble when applied in any thickness) are often prepared with dextrin. The lightfastness of second grade watercolours may not be sufficient to serve for permanent painting: check manufacturers' catalogues for details of lightfastness ratings.

Hand-Prepared Watercolours

Gum arabic is prepared for use as the binding agent for watercolour painting by dissolving in water. This is done by taking one part (by volume) of gum arabic pieces and placing in a pan or glass jar. Six parts (by volume) of boiling water are poured over the gum and this is then left to soak for two to three days. The gum will begin to dissolve within a few minutes but takes a few days to dissolve completely. The dissolved gum solution should be strained through muslin before use to eradicate any impurities. The resultant solution is fairly thick and syrupy. When painted out in this neat form, it has a brittle film.

A plasticising agent is introduced to give the paint film more flexibility. To make the paint lift easily when wetted with a water-loaded brush, a moisturising agent is also added. These additions are usually hygroscopic substances such as hydromel (honey dissolved in water), sugar syrup (sugar dissolved in water) and glycerine.

Hydromel as plasticiser, in combination with glycerine to make the colours moist, can be added to the gum solution. Hydromel makes the paint film more flexible, also aiding the smoothness of the paint mixture. Glycerine also aids flexibility but essentially keeps the watercolour paint moist, making it easy to lift the prepared colour. This is especially important in the commercial manufacture of watercolours in pan form, where the artist needs to be able to touch the wet brush on to the surface of the watercolour pan and lift off colour readily.

For hand-made watercolours, small additions of hydromel and glycerine can be added to the prepared gum solution. The precise measure for each pigment colour will be different: make tests before painting. If the dried colour stays moist, then add less glycerine. Should the dried paint film crack, add more honey. Excess of these materials makes the paint too sticky. The plasticising and moisturising agent can be added to the gum solution, or to the paint mixture later. The gum solution will keep for a few days before spoiling. Specialist artists' pigment suppliers may be able to supply preservatives for water-based paints (e.g. preventol, metatin).

Hand-made watercolour paints can be prepared using this stock solution of gum. Firstly, the dry pigment is combined with distilled water using a glass muller on a toothed glass slab, to form a smooth but thick paste. Distilled water is used, as tap water may contain minerals, typically salts, which can form a cloudy layer on the picture surface. Water that is rich in acids will break down certain pigments but will also have a detrimental effect on the paper support. Distilled water is formed from steam and is therefore relatively pure.

The ground pigment paste can be stored in closed glass jars until required. A little distilled water can be reintroduced should the paste dry out. The wet pigment paste is combined with the gum solution, again using a glass muller. Before painting, make tests on to a good quality watercolour paper. If the test colour is too dry (i.e. chalks when rubbed with the finger), add more gum solution to the pigment paste. If the mixture is too rich, the paint will appear over shiny. Traditionally, watercolours are transparent with a matt sheen when dry.

It is best to make up enough paint for each painting session, rather than try to store the finished colour. It will dry out, or the pigment will separate from the gum solution if put into an empty tube. You can press the paint paste into empty (clean) sea shells. The paste will dry out but remain water-resoluble.

Commercially made watercolours counter such problems by using a different recipe of pigment to binder for each colour. Some colours are still prepared exclusively by hand in watercolour: for example, one firm still hand grind certain colours such as carmine. The high cost of the pigment (a red colourant extracted from the cochineal insect) and the subsequent small paint batches needed, require careful hand grinding of the colour.

Materials for Hand-Prepared Watercolours

- Dry pigments
- Glass muller
- Glass slab, or marble slab
- Gum arabic, crystals, or in solution
- Distilled water
- Empty glass jars, for storing distilled water-pigment pastes
- Glycerine
- Hydromel (honey, dissolved 1:3 in hot water)
- Palette knife
- Kitchen towel
- Empty pans, or sea shells
- Dust mask
- Disposable gloves

Health & Safety Note – treat all pigments with due caution and wear a dust mask when preparing the dry powder into the binding medium. Wear disposable gloves and/or a barrier cream when handling dry pigments.

Lightfastness and Permanence

The permanence of watercolour paintings is an area of much debate among both artists and conservators. In general, watercolour paintings are best kept stored or displayed away from direct sources of sunlight. Because the paint film is thin and transparent, more light transmits through the paint film than is the case with oils or acrylics. As a consequence, pigments that are fugitive (liable to fade), are more likely to show signs of change upon exposure to light. The permanence of a paint does not only concern stability to light: exposure to certain atmospheric conditions (e.g. sulphur in industrial areas), can have a detrimental effect upon some pigments. The chapter on pigments contains more detail of specific instances where this can occur.

In some cases, the permanence of a paint may also be affected by its composition. For example, in second grade paints, additions of filler material could (in theory) reduce the fastness to light of some pigments (typically, some synthetic organic yellows can be rendered less stable to light when over-mixed with whites, including inert whites used as filler). Many manufacturers now include permanence information in their literature along with health and safety information, although there is no obligation to do this.

Supports for Watercolour Painting

Early supports for gum-based painting included parchment made from dried goatskin and also thin ivory plaques. The first papers generally used as a support for aqueous media were made from linen cellulose fibres. While this paper is often thought to be superior, its expense largely precludes its manufacture. Before 1750, in Europe, only laid papers were available, these had a marked ribbed pattern formed from a special wire grid motif on the paper mould. At the close of the 18th century many watercolourists began to prefer wove papers, which had a smoother appearance, close to woven fabric. Tinted papers were often used, or those which were hand coloured by the artist with a ground wash.

Watercolour paper is made with two main constituents, water and cellulose fibres (present in all plants). Cotton and woodpulp are the main sources of cellulose for the production of artists' watercolour papers. Cotton fibres provide the best paper for watercolours, giving a surface that is strong yet durable. The highest grade 100% cotton papers will be free of optical brightners and acid free, so avoiding yellowing or embrittlement with age. Because a paper is acid free, this does not guarantee that over time it will not become affected by acids. Some high grade papers are also buffered with calcium carbonate to help resist the effects of acids. To establish good working practice for watercolour painting always work, if possible, on to 100% cotton rag papers, preferably those that are sold as being buffered with calcium carbonate and state "acid-free" on packaging. "Acid-free" describes papers with a neutral pH (around 6.5), thus giving a fine balance between acids and alkalis.

Papers that contain an acid presence (e.g. newsprint, brown wrapping paper, decorative papers) are prone to deteriorate over time. Often such papers are included within an artist's work (for example in collage) without thought as to their effect on the stability and appearance of the work.

Papermaking

Watercolour paper can be hand-made or mould (machine) made. The first stage in the paper making process is to break down the cellulose fibres with water into a pulp. To do this requires a close supply of pure, reliable water.

A good example is St. Cuthbert's Paper Mill, in Somerset, England. This company produces the Saunders Waterford range of 100% cotton rag watercolour papers, using water drawn from the River Axe. The source of the river is close by, so the quality of the water is reliably constant. This mill uses cotton cellulose fibres which are supplied from farmed, renewable crop plants. To the pulp, sizing agents are introduced, this provides the paper with an internal sizing, which gives artists a support that can withstand its surface being broken, so preventing the cross-bleeding of washes beneath the paper surface.

The fibre and water pulp is then pumped into a vat in which a cylinder, covered with a porous mesh is present. The action of water draining through the mesh pulls the fibre on to the wire and a mass of fibre builds up to form the paper sheet as a continuous length. At this stage, the paper is given an identification watermark, which is produced by fixing wire to the mould cover on which the paper is made. This mark indicates the "right" side of the paper to paint on. Some papers can be painted on both sides, others show a pronounced difference on each surface. The cellulose fibres are distributed randomly in mould made paper production, this helps the structure of the paper, making it stronger. This method imitates the procedure for making hand-made papers, where the fibres are totally random.

The fibres used in the production of commercial machine made papers follow the direction of the movement of the machine, which does not give the paper as much strength as mould made or hand-made papers.

The wet paper sheet is transferred from the cylinder on to woven woollen felts by a process known as "couching" (meaning "to lay down"). The texture of the felt determines the surface of the paper. There are three basic surfaces used for artists' papers: Rough, NOT and Smooth.

Rough (French-Torchon) has the most texture: when watercolour is applied, the pigment settles in the gently pitted surface of the paper. Here, a rough, woven felt has been used to couch the paper from the cylinder.

NOT, or Cold Pressed paper (meaning not pressed with heat) is formed by couching with a random textured felt.

Smooth or Hot Pressed paper (French-Satine) is formed using the same felt but the paper is also passed through hot metal rollers to achieve the smooth surface.

The paper passes through a system of heated rollers to help the drying process (after couching, the paper comprises 80% water content), before being surface sized with a gelatine solution. Gelatine is a refined animal glue, which prevents delicate watercolour paint from sinking into the paper but which is sensitive to the artist's application of colour on to the paper. This process where the paper is dipped into a bath of hot gelatine, forming a skin over the paper surface, is known as “tub” sizing. Mould made papers tend to have two deckle edges (rough, uneven) and two torn or cut edges.

Papers are sold by weight, which is determined by the speed of the rotating cylinder in the production of mould made papers. The weight is expressed in two forms: lb, showing the weight of each ream (500 sheets) of paper, or gsm, giving the number of grams per square metre of paper.

Comparison of Weights of Watercolour Paper

Grams per square metre	**lbs/weight per ream**
	(gsm) (per 500 sheets)
150-160	72
180-200	90
285-300	140
410-425	200
600-640	300
850	400

Papers of 300gsm/140lb tend to be robust enough to accept watercolour without stretching, although saturation and wet in wet washes may cause some cockling of the paper. If in doubt, stretch the paper!

Woodpulp is a cheaper source of cellulose than cotton and therefore provides cheaper artists' paper. However, the strength and durability of such papers can be less than those of 100% cotton rag papers. Some brands contain a mix of the two types.

The best woodpulp papers are those known as “woodfree” paper, composed of chemical woodpulp. Here, the acidic lignin content has been taken out, making yellowing and deterioration of the fibres less likely.

Hand-made papers are prepared by mixing cellulose fibres and sizing agents together in a vat. A mesh frame is lowered into the vat and collects the pulp, with the fibres placed at random. The mesh frame is then pressed against another mesh (the deckle frame) and excess water is forced out. The fibres settle roughly at the four edges, producing the characteristic "deckle" edge. The paper sheets are then left to dry. Sometimes a coating of gelatine surface size is added, although some hand-made papers contain little or no size. The production of hand-made papers continues on a small scale, often meaning that the paper maker will produce a range of tinted papers (by introducing pigment to the paper vat), or may include a mix of other plant fibres, to give added decoration and/or texture to the paper.

Some hand-made papers, due to their surface and lack of size, can seem very absorbent for watercolour painting, seemingly sucking the wet washes into the fibre. This can be partially alleviated by coating the paper with a thinned gelatine solution, which can be bought prepared (expensive) or made up from sheet gelatine (cheap).

Gelatine Solution Recipe for Unsized Papers

One part gelatine (1/8 of a sheet) is immersed in 60-70 parts (by volume) of water. Gently warm the solution in a double boiler, until it becomes clear. Apply while just warm, before the gelatine begins to form a jelly. This solution will spoil in 2-3 days. Adjust the strength of the gelatine to control the absorbency of the paper as required.

Stretching Watercolour Paper

Use a drawing board that is slightly bigger than your sheet of paper. Soak the paper in a bath filled with a couple of inches of cold water. When it is thoroughly immersed, take out of the bath, run off any excess and then lay the paper down on to the board. Take a dry sponge around the edge of the paper where the gum strip is to be placed, this will remove any excess water. Cut strips of brown gum strip to the correct lengths for the paper, then with a slightly damp sponge, make the gum tacky. Stick the gum strip down, with an equal proportion of paper to board covered. Run a dry sponge round the fixed down gum strip to take off any excess water. Leave to dry: a hairdryer can be used to speed this process.

Once dry, the paper is ready to paint on and should be free of cockles, providing a tight drum surface, although saturation with water will relax the paper somewhat.

At this stretched stage, it is possible to hand tint white watercolour papers, by using pigment mixed into a thinned gum solution, or you can apply a layer of thinned watercolour. Flat, even washes can be obtained by using a wide, flat ox hair varnish brush, or a similar size flat synthetic hair brush.

Watercolour paper is sold in sheet form. Full Imperial sheet size is usually 560mm x 760mm/22 x 30 inches, although larger sheet sizes are also available. In addition, many mills can supply their papers in roll form (more economical) and in the form of pads, quarter sheets and tear-off blocks. Watercolour blocks are very useful when working outdoors, as the paper is already stretched and remains stretched while working. Despite being an expensive and perhaps lazy approach, it does allow the artist to concentrate wholly on painting.

Good quality watercolour paper should be able to withstand a good deal of brush scrubbing and sponging. Often, a wash will need to be lifted out: this can be done by flooding the paper with water and applying a dry natural sea sponge which will suck up the colour. It should be possible to apply firm pressure to the paper in this manner, to lift out colour. The same procedure can be done with a sable or squirrel hair brush, by wetting the paper then lifting out with a dry brush into the damp paper. Watercolour should re-dissolve when wet, with the exception of certain synthetic organic pigments, which tend to leave a stain behind on the paper.

Care and Storage of Watercolours

Cleaning Dirt from Watercolour Paintings

Dust and dry dirt particles can be removed from watercolour paper by using a soft dry brush only. A soft eraser may also be useful but this may damage the paint surface. It is unwise to introduce any solvents or chemicals: take the painting to a trained paper conservator if further treatment is required.

Choosing Framing Materials

Use only archival grade mounts, adhesives, adhesive tapes and backing boards when framing watercolours. Cheap materials that contain acids can turn yellow-brown but may also migrate to the painting, leading to possible discoloration of the paper and infiltration of the paper fibres.

Storage

Watercolours should be carefully stored flat and away from damp. Mold growth is the most common result of exposure to damp, resulting in foxing (brown stains) that look like spots of iron on the paper. These can be treated by a trained paper conservator but preservation is always better than cure.

If possible, paintings should be stored in a portfolio or closed plan chest, away from extremes of direct sunlight and heat. It is preferable to show watercolour paintings under subdued light, although this is not always practical. Prolonged exposure to daylight should be avoided and especially to direct sunlight. Avoid the use of colours which you know are prone to fade, in transparent washes against white grounds or in admixtures with white, where the colour will be bleached out. Colours such as alizarin crimson may last longer when painted out over a dark underpainting than when applied thinly over a bright white ground.

Auxiliary Materials

Natural Sponge

Natural sponges, usually from Greece are important to the watercolourist, for lifting out unwanted colour, dabbing, smearing and soaking up water from the paper surface. Sponges are sold in sizes ranging from 1 to 4 inches in diameter, although larger flat “Elephant Ear” and round “Wool” sponges are also available from specialist suppliers.

Sponges should be soft enough to meet the delicate surface of paper without scratching. Blotting paper may also serve well for lifting out washes and spilt water.

Scalpel

Useful tools for scratching the paper surface, to create highlights through the paint surface, scalpels are sold in a variety of shapes. Other sharp knives, such as penknives can be utilised, or other abrasive materials, such as sand (glass) paper.

Palettes

Ceramic palettes, usually available in a variety of sizes and shapes are considered best for watercolour painting. They are superior to plastic types because staining colours can be cleaned completely from the ceramic surface. Enamelled metal palettes are also perfect as they too can be easily cleaned. Many painters prefer to improvise, especially when working on a large scale. Plastic baker’s trays for example are good for making up large amounts of wash.

Painting Additives

Oxgall

A liquid that is added to painting water to improve the flow of watercolours, enabling colour to disperse readily. Add sparingly. Usually sold in clarified form, suitably diluted. Neat oxgall is also available although this is rather smelly!

Gum Water

Basic gum arabic solution in water. Sometimes has additions of hydromel or sugar syrup to aid flexibility. Added to watercolour paint to introduce lustre to paint film, or diluted further with water to improve flow.

Impasto Gels

Painting thickly with watercolour goes against the traditional technique of application in thin layers. However, many artists wish to use their watercolours with impasto. Some manufacturers offer pasty gel-type mediums specifically for watercolour, which act as thickening additives to watercolour or gouache.

Prepared Size

Used to reduce the absorbency of watercolour paper. Apply to the surface of the paper and leave to dry before painting. Made from gelatine, available in a prepared solution, or in dry sheet form.

Masking Fluid

A latex solution, which can be applied to paper to give a water-impervious film, to protect selected areas when applying colour in broad washes. It can be removed from suitable papers (make tests first) by peeling or rubbing gently. It should not be applied on top of water resoluble colour, as it may lift the paint on removal. Supplied in colourless or tinted form. Brushes used to apply masking fluid need to be washed straight away in warm, soapy water, as once dry, the masking fluid is virtually impossible to remove from brush hairs.

Varnishes

Varnishing is not appropriate to watercolour painting, as this would destroy the matt film of the paint surface. Paintings should instead be kept in the correct storage environment.

A light spray of archival standard fixative will afford invisible protection without altering colour tones or the appearance of the paint sheen.

Diluent

The solvent or diluent for aqueous paint media is water, or preferably distilled water. Avoid saltwater and tap water, which contain potentially harmful mineral elements. Distilled water can be admixed with a small proportion of gum water solution to help retain the lustre of watercolour in extreme washes. An addition of oxgall (a couple of drops only) to painting water aids flow and dispersion.

Combining Watercolour and Other Media

Watercolour is often used with other media. For example, charcoal, pencil or pastel are frequently used in combination with watercolour. If drawn marks are to be overpainted without smudging, it is a good idea to give the paper surface a light coat of an archival spray fixative. This will stabilise the drawn area, so that washes of watercolour do not dislodge the drawn marks. Sometimes, soft pastel is applied on top of dried watercolour paint. Because pastel grips best to a toothy support, Rough watercolour papers are a good choice for this method of working. The fixative mentioned is recommended because it does not build up a sheen, is very flexible, water-clear and can be overpainted with almost any art medium.

Acrylic Materials and Watercolour

Acrylic colours can be used to imitate watercolour technique. When strongly diluted with water, acrylic paints can be used to apply thin washes of colour on to any dirt and grease-free support. It is possible to use acrylics in combination with watercolour, although it is best to leave coats of applied paint to dry thoroughly before overpainting (i.e. do not intermix acrylic and watercolour, as the two materials have different drying characteristics.) To achieve a finish as close as possible to traditional watercolour, matt acrylic paint, or acrylic paint mixed with a matt medium is recommended. Sometimes it is useful to introduce a specific acrylic colour to achieve an effect that is difficult in true watercolour. For example, most acrylic paint ranges include iridescent or interference colours, which are not available in watercolour ranges. These pearlised colours give a lustre sheen and work best on to dark backgrounds.

GOUACHE

The term "gouache" is the French equivalent of the Italian "*a guazzo*", meaning literally, "a muddy pool". In English, traditionally, gouache paints are also known as "body colour", being watercolour with a heavier body, where all colours are rendered with equal opacity.

Typically, gouache paints are derived from a mixture of pigment and gum arabic, with a filler such as blanc fix admixed to certain colours, to achieve opacity, and to help register a flat, velvety matt dried paint film. In recent years, some manufacturers have introduced gouache paint systems based on acrylic polymer emulsion mixed with a starch binder, thus providing a more flexible dry paint film.

In essence, we can think of gouache colour as being opaque watercolour. In true watercolour technique, sometimes chinese white is admixed to transparent colours to render them more opaque, to give them "body". This idea is taken a step further with gouache colours, where all the colours in each range will have been admixed with a low tinting strength white (blanc fix, also known as permanent white, barium sulphate). The resultant paint dries to a matt, velvety finish, light being absorbed rather than transmitted, as would be the case with transparent watercolour.

Of course it is more than possible to combine watercolour and gouache technique, thus fusing transparent and opaque areas. Because gouache is a water-thinning paint system, one can always thin out colour towards transparent glazes as required, although the resultant chroma of the dried paint film will be less glowing, less intense than a watercolour.

The origins of gouache painting stem from true tempera painting. While egg tempera painting was perhaps best suited to application on to solid, gessoed panels, a simple tempera paint made from pigment and a water-resoluble gum (gum arabic, gum cherry) could be used on parchment, or more recently paper, with similar results to egg tempera. This "gum tempera" was a little easier to prepare than true egg tempera, as the colour could be reconstituted on the palette when dry, so that mixed-up colour could be used and re-used as required.

Artists' Gouache and Designers' Gouache

Tubed gouache colours tend to be presented in two formats, as artists' (permanent) colours, or as designers' colour (for reproduction work). With designers' gouache, the need for lightfastness is not as acute, because the kind of work undertaken may only need to last a relatively short time: camera-ready artwork may require very bright colours, often based on dyes that can be replicated by commercial printing techniques. As a consequence, often designers' gouache ranges contain colours based on fugitive pigments or dyes. A good example are the fluorescent pigments, which are very liable to fading when exposed to daylight. These are often found in designers' gouache ranges, but one should try to avoid using them for permanent artworks. Often, designers' ranges include colours based on dyes that are not only liable to fading, but which "run" when re-wetted on the paper, often staining/bleeding into other colours. While ranges marked as designer gouache do contain more permanent colours, one needs to read the colour chart carefully before choosing paints, to ascertain the permanence of the colours. The colour chart usually has a star rating guide for lightfastness: choose only those with the best resistance to fading.

Artists' gouache ranges by contrast provide relatively permanent colours, where the paint has been manufactured with permanent artworks in mind. Even so, one should still look at the colour chart and pick out those with the best lightfastness. This is essential, because it is likely that each pigment will have been reduced in tinting strength due to the admixture with a filler (e.g. blanc fix). For some pigments (e.g. alizarin crimson), this admixture of white pigment can reduce the fastness to light and encourage fading upon exposure to daylight.

A simple way to test the resistance to fading of gouache colour, is to make some paint-outs on to paper: one application of neat colour, then another, admixed 50/50 with white. When dry, cover one half of each painted-out strip of colour, and place the paper or card against a window, facing daylight. Leave for about one month and then see if there is any perceptible change in hue. Gouache colours based on dyes or fugitive pigments tend to lose their brilliance, or in the most extreme cases, fade out altogether.

Hand-Made Gouache Colours

Gouache colours are fairly easy to prepare using dry pigment, because the pigment and binder do not need to be mulled expertly to achieve a good paint. This is because each colour is admixed with blanc fix, which absorbs the chosen pigments and helps to provide a soft, stiff paste.

Methods for Making Gouache Paints

On to a glass slab, with a straight palette knife, mix a stiff paste of distilled water and dry pigment. To this, add about 15-20% blanc fix, adding a little water as required. The resultant paste should be stiff rather than sloppy. This mixture can be stored for few days but is best used straight away, so make only enough colour for each painting session. To the pigment paste, add a quantity of binder, just enough to wet the pigment and make it glossy in this wet state. Make some tests before painting: if the paint dries glossy then too much binder has been added; on the other hand, if the dry paint is chalky and rubs off when rubbed lightly with a finger, a little more binder is required. It is a delicate balance. However, it is very good practice to prepare your colours in this way, as one quickly learns how each pigment behaves. The binder for making gouache paints is normally a gum arabic solution. Each manufacturer of watercolour usually provides a gum arabic based paint medium, which can be used as the basic binder in gouache paint. Alternatively you can prepare it yourself from the dry gum arabic.

Take one part (by volume) of gum arabic pieces, place in a container (e.g. glass jar). Pour into the container 12 parts of boiled water from the kettle. Stir every 15 minutes for a few hours, then leave to soak overnight. The next day, the gum will have dissolved to a brackish, honey-like consistency. This mixture should be strained/sieved to remove any impurities from the gum pieces, and can then be stored for a few days before spoiling. Some recipes call for the use of dextrin (starch) in conjunction with gum arabic. This simple starch solution (it dissolves quickly in warmish-water) renders the paint more resoluble and also improves the matt quality of the dried paint film.

Alternatively, a resoluble acrylic binder can be used when making gouache or watercolour paints by hand. One advantage of using this is that the binder keeps indefinitely and remains water-resoluble when dry, so that colours can be kept for longer periods.

Another method for making gouache paints uses the same binders as already discussed, but utilises pre-prepared pigment pastes, or colour pastes. These liquid pastes consist of pigment suspended in water, with a biocide and flow agents. In this method, the colour paste will not spoil, so has a very long shelf life. To the colour paste, 15-20% of blanc fix is added. The binder is then added as required.

For both methods, the author has found that a cup-cake baking tray is the best palette for keeping colours. The deep wells allow for a plentiful quantity of prepared paint-paste, while the intervening ridges can be used for colour mixing.

Suggested Pigments for Hand-Made Gouache Paint

This list of pigments concentrates on naturally opaque colours. To these opaque pigments only a small amount of blanc fix needs to be added. To the transparent colours (marked *), a greater proportion of blanc fix is added to achieve opacity.

Cadmium yellow lemon
Cadmium yellow medium
Cadmium orange
Cadmium red medium
Cadmium bordeaux (a deep rich, red-violet)
Cadmium brown (a deep red-brown)
Chrome oxide green
Phthalocyanine green* (with blanc fix, tends towards emerald green)
Phthalocyanine blue* (with blanc fix, tends towards sky blue)
Ultramarine blue*
Ultramarine violet*
Quinacridone red* (for a bright fuschia pink)
Titanium orange
Mars (iron oxide) yellow
Mars (iron oxide) red
Mars (iron oxide) violet
Mars (iron oxide) brown
Mars (iron oxide) black
Titanium white

Application

Traditionally, gouache colours are broken against each other, to accentuate the contrast between them. However, it can be equally effective to mix the colours on the paper (truly a muddy pool of colour). Because the paint is thicker than watercolour, having a denser structure, it is ideal for pushing about on the surface. Diluting the colour just a touch when applying, allows it to slip off the brush rather than dragging across the paper. A slick consistency, which does not show brushmarks when dry, is ideal. Obviously, everyone has their own technique and preferences. Some will prefer to dab, others to apply thinner paint, etc.

When overpainting, wait for each layer to dry before proceeding. It should be possible to overlay colour without picking up from the previous layer. However, if one agitates the surface of the dry layer with a wet brush, it will of course reconstitute that layer of paint. One can learn to utilise these properties judiciously in the working process.

Supports

Supports suitable for gouache include the standard watercolour papers: 300gsm papers, or preferably heavier weights, to give a more card-like structure are ideal. For example, 600gsm Saunders Waterford NOT paper, provides a slightly pitted surface and a very strong, durable support, which does not cockle when wet colour is applied. Other possible supports include parchment vellum, matt acrylic gesso primed paper, board or canvas fixed to a rigid support. If you use an acrylic priming, make sure that it is very matt when dry, as the glossy types tend to resist applied gouache paint.

Preservation and Storage of Work

Like watercolour, gouache paintings are relatively fragile artworks. They should be stored away from direct sunlight, preferably in a closed portfolio. A sheet of acid-free tissue paper will protect the matt paint surface from scratches or marking, when stored flat. Finished work can be glazed for best protection. Varnishing is not recommended, as this can change the matt, velvety paint finish. A light spray of fixative will preserve the paint surface without darkening the tones too much.

Alternative Water-Based Binding Agents

A number of protein glues and starch-glues can be used with dry pigment to create new binding systems, which do not correspond readily to manufactured paints. However, they should be considered by artists because they may offer a cost-effective way to make simple paintings, usually on to paper, which emphasise the characteristics of the pigments used.

Gum Tragacanth

Natural tree gums have been used by artists for many centuries. Gum tragacanth swells in water but does not completely dissolve.

Typical Recipe for Gum Tragacanth Solution

Gum tragacanth, powder	1 part
Cold water	20 parts

Ideally, the cold water needs to be distilled water, or water from a boiled kettle left to cool. Tap water tends to promote mould growth.

The powdered gum is left to soak in the water for 1-2 days. The gum swells and forms a kind of suspension, which is quite lumpy, or gel-like. After 2 days, press the whole mixture through muslin, leaving behind most of the lumps/gel. The strained liquid can then be prepared with dry pigments to make a very matt watercolour, which gives a dry, velvety paint film. Gum tragacanth is commonly used as a binder for soft pastels, due to its soft, forgiving qualities.

For pastel making, even weaker solutions of gum can be used: just enough to hold the pigment together in a rolled stick-form.

Because tragacanth solution spoils quickly, it needs to be made then used. The exact amount of pigment to binder required for making a simple watercolour will vary from pigment to pigment. Even when the amount of binder to pigment is very high, the paint film tends to dry to be dead-matt rather than glossy. As a consequence, artists can make a simple paint using tragacanth solution which has far more binder to pigment, without too much trouble. The resultant paint can be applied to any watercolour paper.

Dextrin

To make a very simple water-based paint, dextrin (starch powder), is mixed with water.

Dextrin, powder	1 part
Hot water	20 parts

Boil a kettle, then leave to stand for 5-10 minutes. Pour this hot water over the dextrin powder, in a clean vessel. Leave to stand for 10-15 minutes, stirring every now and then to free any lumps. The resultant thin syrup can be used as a basic binder for pigments and the paint produced in this way can be applied to any watercolour paper. If the syrup is too rich in binder, it will feel slightly sticky when dry on the paper. If this happens, simply dilute the stock solution as required. Dextrin is an economic alternative to gum arabic and gum tragacanth.

Methylcellulose (Tylose)

This type of converted starch is sold in powder form and swells when mixed with water to provide a lump-free solution, which can be used as a binder for making watercolours, gouache, or soft pastels. It is offered in a variety of thicknesses, according to end use. For paint making, methylcellulose with a low viscosity (e.g. MH

300) is recommended. It has little or no binding power, so resultant paint films may be dusty, requiring an application of fixative spray, once dried.

Methylcellulose	1 part
Cold water	30 parts

Leave this mixture to stand for 1-2 days, stir occasionally. Once the mixture forms a clear solution, free of lumps, it can be used as a simple binder. It can also be added to raw acrylic resin dispersions in small amounts (10-15%), to give a matt, gently absorbent acrylic paint. Solutions of methylcellulose tend to absorb pigment powder readily, so can be used to make quick, economic paints. The solution remains very resoluble with water once dried and needs to be kept away from damp. Soft pastels can also be made with methylcellulose (see the chapter on Soft Pastel Painting).

Casein

A dried milk product, casein is a high protein binder for pigments. The powder only forms a solution (or rather an emulsion) in water, when ammonium carbonate is added to the mixture. This emulsifying agent allows the casein to take up the water to form a swollen paste. This paste is further diluted to a single cream consistency. Casein has a high glue strength: as a consequence, it provides a very durable, hard-wearing matt paint film. Sadly, solutions of casein tend to spoil within days, so need to be prepared and used immediately. The dried paint film is effectively non-resoluble with water, so is nominally damp-resistant.

Recipe for Simple Casein Paint

Casein powder (lactic acid)	2 parts
Cold water	8 parts
Ammonium carbonate, powder	1 part

Add the water to the casein powder. Slowly stir in the ammonium carbonate. Leave to stand for one hour, stir occasionally. The mixture swells to form a brackish paste. Add a further 8 parts of water slowly, stirring all the while, to achieve a smooth single cream consistency. Add more water as required. The mixture and resultant paint can be further diluted with water.

To the casein solution, add the desired quantity of pigment. Because casein is such a strong binder, it can be overloaded with pigment to some extent while still adhering to the support. Casein paint can be applied thinly to watercolour paper, or on to panels prepared with gesso made with animal glue and chalk. Multiple coats of casein paints tend to be unsuccessful, due to the extreme strength of the binder. Make sure that subsequent coats are weaker (diluted) to counter this defect. Casein is a quick, economic pigment binder, which can be used to show how pigments behave (i.e. transparency and opacity are clearly seen when mixed with the casein binder).

Casein paint can be applied to stiff watercolour papers, or on to panels prepared with casein gesso (where casein is used as the binding agent for chalk). Care must be taken during the preparation of casein gesso, to ensure that the glue strength of the base coat is stronger than that of subsequent coats (i.e. each successive coat is required to be slightly more dilute than the previous, to prevent the gesso layers shearing away from each other). Applied layers of paint follow the same basic principle, as already mentioned.

Egg White, Glair

In medieval illumination, the white of the egg was commonly used as a binder for pigment. This egg white, or glair, is almost wholly protein based and forms a strong, thin binding, which is especially useful for pale colours. To prepare, the egg white is whisked until the liquid becomes a foaming froth. The quickest way to do this is with an electric food mixer. Once the egg white turns entirely to a froth, it is left to stand for 2-3 hours. After this time, part of the mixture will be liquid, part will still be froth. Pour off the liquid into a clean container: this is the binder, “glair”. Throw away the remaining froth.

The glair can be mixed with pigment and applied to watercolour paper, or gesso panels. The original support for glair-based paint would have been goatskin parchment (vellum), where a thin coat of a gesso-like preparation was used as a ground on the areas to be painted (e.g. letter capitals on illuminated manuscripts etc).

Klucel (Hydroxi-propyl-cellulose)

Klucel is a modern, clean starch-based binding agent, sold in a variety of viscosities. The thicker types may be unusable as paint binders, being too viscous to manipulate successfully.

Klucel can be solved 10% powder to cold water, to form a clear, viscous liquid. Leave to stand for 1-2 days then strain through mesh to remove any lumps. Klucel made up this way (using distilled cold water) keeps for many months before spoiling (it does not attract microbes). It can be further diluted with cold water as required.

Add the klucel solution to dry pigment and stir well. Normally, the pigment is readily absorbed into the klucel binder. A little alcohol can be added to improve wetting of pigment, especially when using the synthetic organic pigments. Pigments can be first mulled with distilled water on a glass plate with glass muller to improve their wetting, as required.

It is recommended to prepare pigments into klucel using the 10% concentration, then dilute later to achieve thinner paint films. Klucel dries to a flat, neutral finish: excessive use of binder does not increase the gloss of the paint film, especially when filler (e.g. blanc fix) is added. Paints made with mixtures of klucel/pigment/filler tend to give flat, matt, paint films. The dried paint film is insoluble with warm water, but will pick-up when cold water is applied and agitated on to the paint surface. This system allows dried, or recently dried colours to be overpainted without discoloration or disturbance.

Klucel-based paints can be applied to stiffish watercolour papers and to gesso-primed panels. Klucel also dissolves into alcohol, to make a consolidant often used in paper conservation.

Animal Skin/Bone Glues

Any type of protein/starch glue can be used to bind pigments, but the characteristic properties of the chosen binder may affect the longevity of the artwork.

In the case of animal skin/bone glues, the dried glue film remains water-receptive (hygroscopic) and sensitive to moisture. If agitated with warm water, a paint film based on this glue may become reconstituted (or at least slightly sticky). Such paint films are also very prone to deterioration from damp and need to be stored in a dry, ambient atmosphere. Examples of paintings made on to stretched linen canvas using animal skin glue bindings have survived many hundreds of years. However, the initial rich gleam produced by animal skin/bone glue paint films soon becomes dull, matt in appearance. Over time, the paint film becomes very dry and progressively harder (less flexible). As a consequence, chalking of the paint film is common with age.

Weak solutions of animal skin glues (e.g. rabbit glue) can be prepared and used to bind dry pigment. Such binders readily absorb most pigments, especially earth pigments, mineral pigments and other large-particle size pigments. With finer particle pigments, a 5% addition of water-free alcohol acts as a wetting agent (e.g. with alizarin crimson, prussian blue). When the binding is relatively dilute (e.g. one part glue to 30 parts water), the paint film is more or less water-clear. Stronger glues have a slight brownish cast, depending on the quality of glue used. Laying down multiple layers of such glue bindings can be rather tricky, as the previous layer will want to "pick-up" if agitated. However, careful brushing of thin glazes can avoid this. As with casein, the glue strength is of great importance. The first layer needs to be slightly stronger than the next, and so on. This requires the addition of a small amount of water at each layer stage. To keep animal skin or bone glues in a fluid solution form, it is best to keep the glue bath just warm. Rather than contacting with a direct heat source, the glue container simply stands in a larger bath/vessel containing water from a recently boiled kettle. This method will keep the glue warm for 10-15 minutes at a time: as the glue returns to a jelly, simply re-boil the kettle and replace the hot water.

Animal glues may be sourced from skins (hides), usually from cattle, or from bones and hooves (gelatine). While rabbit glue requires warming to form a solution, gelatine swells readily in cold water and requires only modest heat (10°C) to form a solution. Gelatine is usually more refined than grains or cubes of animal skin glue, with a paler colour and contains fewer impurities. Recipes vary according to the intended use, a simple glue is made in the ratio of one part gelatine (by volume) to 10 parts of water. Upon swelling and forming a solution, then cooling, this ratio should provide a softish-jelly. When working with pale and delicate colours (e.g. mineral blues such as lapis lazuli, or azurite), using gelatine as a binder, rather than heavier coloured bindings (e.g. egg yolk), helps to preserve subtle colour values. Although gelatine can be considered less strong than skin glue as a binder, it should have greater flexibility.

Isinglass

In the Russian icon tradition, the glue used in the preparation of the painting ground (gesso) and also in some cases, the pigment binder, is derived from isinglass, a pale, almost colourless glue from the swim bladder of the sturgeon fish. Since the fall of the Soviet Union, the supply of isinglass has become rather limited, although at present, Andrei Andreev has procured an ongoing source of bladders, which are collected at the mouth of the Volga river once a year, dried and sold by weight. The best quality "Salianski" glue is unrefined and has a pale yellow-brown colour. This pale colour is negligible in terms of its use as a binder or glue for painting grounds. Unrefined isinglass has greater flexibility than the cleaned-refined type (which appears as a translucent white membrane). Some isinglass on the market may be from other sources, usually from South American sturgeon fish.

Isinglass has greater binding strength than gelatine and skin glues. To form into a usable solution, it is left to soak for 3-4 hours in distilled water. At this stage, the glue mass swells. The glue is removed from the water and carefully wrung to remove excess water. Wrap the glue mass in cotton muslin, and gently squeeze to remove as much water as possible. The remaining mass of glue is then placed in a double boiler and left to warm through on a low heat (no more than 60°C), so that the glue forms a clear solution. Once the glue is clarified, strain through muslin to remove impurities. In this form, the isinglass glue can be used, while still just warm, and makes a fine, almost water-clear binding for pigments. Between each applied layer, leave the glue to dry off, or pick-up may occur. The stock solution of isinglass will keep for a few days and can be stored in a fridge at about 6°C. The cooled gel can be re-warmed as required, although this process tends to give progressively weaker glue. Isinglass has excellent flexibility and is the chosen glue for repairing tapestry work due to its almost invisible colour and elasticity.

Starch Pastes

Starch, in the form of powder can be obtained from wheat, rye, rice or arrowroot. These powders are prepared into starch paste by combination with cold water, just enough to form a brackish, viscous paste. To this paste, an equal quantity of recently boiled water (i.e. very hot) is added and stirred together to form a syrup with the consistency of double cream. This simple starch paste is most often used in the repair of paper artefacts (the starch contains no sulphur or nitrogen, so acts as a neutral adhesive). However, the glue strength is not high and as a binder for pigment, such pastes are less than reliable. The resultant paint film is very dry (can rub off easily), although this method does show the exact nuance of the pigment used. It may be possible to use starch+pigment to execute the painting on to paper, then, once dry to apply a spray fixative to help hold the fragile surface to the paper support. In this way, starch paste can be combined with soft pastel painting techniques to give a similar appearance.

Simple pigment-starch pastes are often used in printmaking techniques, for woodblock printing. In this instance, fat (thick) starch pastes, containing a small amount of pigment are ideal for pressing against incised woodblocks to gain an embossed impression. During the application of pressure, excess water in the starch paste is pushed out and a soft, fine layer of colour is transferred on to the (usually delicate, soft) paper. In the restoration trade, old recipes for the relining of canvas mention the combination of starch glues (wheat, rye, etc.) with venice turpentine, to make a tacky adhesive.

Soft Pastel Painting

When dry pigment is combined with an extremely weak binding agent, cylindrical sticks of pastel, usually referred to as “soft pastel” can be formed, thereby allowing the artist to apply colour directly to a specially prepared paper support.

The degree of softness of the pastel stick is governed by the strength of the binding agent used but also the exact combination of dry raw materials. If the binding agent is too strong, the resultant pastel stick is hard, possibly unworkable over the paper support. Some pastel brands are softer in feel than others: this is more often than not a conscious decision by the manufacturer. Just as different brands of oil colour will have different consistencies, colour strengths, degree of matt or gloss, so the various brands of pastel colours on the market can vary in texture. Similarly, if the binding agent is too weak, the pastel stick may crumble easily when moderate pressure is applied.

Pastel sticks are made by combining a number of dry raw materials into a weak binder. For example, pigment is often admixed with china clay and/or talc to help produce a soft, velvety mark, when the resultant pastel stick is applied to the support. Without the addition of these dry filler materials, the pastel stick may be too hard and scratchy to work well. As a consequence, the manufacturing of pastel sticks is not always straightforward: each individual pigment will require a separate recipe, in order to produce a pastel stick with the optimum qualities of softness and colour strength.

From the recipes given in this chapter, artists can prepare their own pastel sticks for pastel painting. The recipes provide a starting point, and it should be noted that the strength of binder and exact combination of raw material differs from one colour to another. Because pigments vary from source to source, the recipes given here are a guide only, from which one expects that adjustments may need to be made in order to create the desired effect when painting.

Supports for Pastel Painting

In many ways, the softness of the pastel stick relates directly to the type of support used. If very soft pastel is applied to a highly abrasive ground, then the pastel stick will be quickly used up: in the worst case, it will simply crumble into the paper surface. As a consequence, the choice of support is crucial.

If one uses smooth paper, when the pastel stick is applied to the surface, the pigment particles have little or nothing to catch on to. Ideally, the applied pastel colour becomes caught in the structure of the support. For this reason, mildly abrasive grounds, for example, those prepared with pumice powder in a water-based glue are quite successful. Similarly, papers with a pronounced grain (e.g. rough watercolour paper, or special pitted surface pastel papers) are commonly employed. The degree to which the pastel pigment is caught on the surface of the support also governs the amount of "fixing" required. Many theories exist as to the best way to "fix" the particles of pigment to the support surface. It is probably best to use the minimum amount of fixative, in order to avoid a change in colour tones. Whenever fixative is applied to pastel paintings, it saturates the pigment dust, coating the particles with resin. Consequently, the colour tones may darken, thereby negating the appearance of the painted image.

The best solution seems to be to apply only the minimum amount of fixative, in combination with pastel applied to a relatively toothy support, where much of the pigment dust is held in place by the texture of the support.

Another factor to consider, is the best way to exhibit pastel paintings. In order to protect the fragile painting surface, they are usually shown behind glass (glazed). This prevents the pigment dust from being disturbed but at the same time introduces a change in the way light falls on the surface (i.e. it has to pass through the glass before hitting the painting surface). It is possible to attach the painting (for example if done on paper) to a second support, such as an MDF panel, and to show the painting without glass protection. This obviously makes handling and display more of an issue. It may also be necessary to fix the surface more comprehensively when showing work in this manner.

While the surface of the pastel painting is fragile and requires careful handling, so the type of support used needs to conform to notions of longevity and durability. The best choice is to work on to acid-free papers, which do not discolour over time or promote the activity of acid compounds. Similarly, when choosing abrasive supports, ensure that the substrate on to which the abrasive ground is applied is acid-free and of archival quality. In respect to this, sand paper (glass paper) from the hardware store is wholly unsuitable. The thick card backing to such papers is extremely acid-rich and will discolour over time. This discoloration can spread to the face of the painting and influence colour tones. Such acidic papers may also decompose readily, especially in combination with mild damp.

Commercial Pastel Papers

Commercially prepared pastel papers tend to have a degree of texture, but this is not particularly pronounced. As a consequence, most commercially prepared papers catch and hold less pigment dust than hand-prepared ones, leading, inevitably to the application of multiple coats of fixative. While the surface of such papers tends to be slightly pitted, rather than abrasive, they may serve perfectly well for studies made in pastel where minimal amounts of colour are applied - for example in the context of a life drawing class, where perhaps only two or three colours are used during the drawing/painting process.

Commercial pastel papers are often sold in pads or blocks, with each page interleaved with a sheet of tissue or glassine paper to help prevent smudging of the applied pastel.

Pastel paper is often marketed in a range of colours, to provide a tinted ground. However, the permanence of coloured papers is not always disclosed by the manufacturer. Often such papers are coloured by dyes that have a tendency to fade. This may be especially so with strong, bright colours.

Flock/Velour Paper

In French pastel painting, a special support based on velvet flocking, glued to a paper backing has long been used. This surface has a soft, velvety texture which catches pastel dust successfully but also allows for a large degree of blending and smudging on the painting surface. With such papers, often the paper and the flocking have been coloured to give a tinted ground. Again, the exact properties may not be disclosed by the manufacturer. For example, the colouring may be dye-based and thereby more liable to fade upon exposure to light.

Cork Boards

Finely ground cork can be mixed with glue and applied to a thick paper or cardboard backing to provide a suitable support for pastel painting. In the author's experience, such grounds should not come into contact with water (i.e. not suitable for mixed media, with additions of watercolour, gouache, etc), nor should they be rubbed aggressively, as the cork soon detaches itself from the backing.

Hand-Made Supports

The easiest pastel support to hand prepare is that which is made from pumice powder (pulverised volcanic pumice stone), mixed into a solution of rabbit glue. This support is slightly toothy, thereby allowing the pastel pigment particles to be attached to the surface and subsequently reducing the need for excessive fixing upon completion of the painting.

Recipe for Pumice-Glue Ground

The glue is first prepared into a solution:

Rabbit glue, grains	1 part
Cold water	15 parts

The glue is placed in a clean vessel (e.g. glass jar), to which the cold water is slowly added. Leave the glue to soak for 30 minutes or so. During this time, the glue swells slightly but does not form a clear solution. Boil a kettle and deposit the boiled water into another (larger) container, into which the glue vessel is placed (i.e. a warm-water bath). The action of the boiled water on the glue vessel causes the glue to clarify and form a solution. Into the now warm glue solution, a percentage of pumice powder (perhaps 20-30% pumice to the volume of glue solution) is added. Stir vigorously, so that the glue saturates the pumice particles. The mixture is then applied using a wide hog varnish brush (40-50mm wide), on to the chosen paper surface. The pumice-glue mixture needs to be applied while still warm: if it cools too much, the glue will set as a jelly. If this happens, simply sit the mixture in a bath of warm water again to re-constitute.

Each time the glue-pumice mix is applied to the paper surface, it is imperative that the mixture is stirred to keep the pumice particles in suspension, thereby producing a relatively even film of application over the paper surface. Upon drying, check that the pumice particles are firmly attached to the paper surface. Wait 24 hours to do this, so that all moisture has evaporated. If the pumice particles are not properly attached to the paper surface, try adding more glue the next time, or reducing the amount of pumice used. One thin application is best, so that the pumice powder stands up against the surface of the paper just enough to catch the pastel pigment particles. This pumice-glue ground can be modified by the addition of a small amount of dry pigment, to give a tinted ground. If no pigment is added, the colour is a soft beige or beige-grey, depending on the colour of the pumice. By adding small amounts of dry pigment (e.g. a natural earth pigment such as yellow ochre), the dull colour of the pumice is hidden. If too much pigment is added, the tooth of the pumice may become lost.

Some pigments have a toothy nature and can be applied in place of the pumice to act as both a colourant and give an abrasive quality. For example:

- Green quartz, fuchsite
- Aergirine (iron silicate green)
- Azurite
- Malachite
- Sodalite
- Basalt
- Iron glimmer (iron ore, ranging from 0-150 micron size)
- Cast iron powder
- Stainless steel powder
- Glass pigments (which range from 0-125 micron size)
- Many types of earth pigment have coarse structures

All these coarse textured pigments could be combined with the glue solution to give coloured pastel grounds.

Coarse Pastel Ground

In order to bind large, coarse pigments or other material (e.g. coarse marble dusts, quartz chips), a stronger water-based protein glue, such as casein could be used. Casein has great adhesive strength and dries fast to a neutral, mattish finish.

Recipe for Casein as an Adhesive for Large Particle Size Pigments/Filler:

Casein (lactic acid)	2 parts
Ammonium carbonate	1 part
Cold water	8 parts

The powdered casein and water are combined together. The ammonium carbonate is slowly stirred into this mixture and acts as an emulsifying agent, to create a smooth mixture. The ammonium carbonate tends to cause swelling or effervescence. Upon being left to stand for 30 minutes or so, the mixture calms down to give a smooth, thick paste. In this form, the casein can be used as a strong glue, especially when attempting to adhere large particulate structures to stiff paper (e.g. quartz chips). The mixture can be diluted with more cold water as required. The casein solution is good for 2-3 days before it begins to turn rancid and becomes smelly.

When combining with aggregates such as marble dust or quartz chips, apply only one coat of the casein to the support. Multiple coats may delaminate from the support, as the casein glue is so strong that the top coat will stick to the first coat and upon drying want to shear away from the support. Multiple coats may also lead to cracking. Upon drying, casein always has a neutral, dry finish. This makes it especially suitable for use with larger particle size aggregates such as marble dust and quartz chips, where the applied material will dry off to give a stone-like effect. The application of such aggregates obviously adds weight to the support. It may therefore be more appropriate to apply such pastel grounds on to boards (e.g. MDF panel of 15mm + thickness). If working on to paper, choose heavy watercolour paper (425 to 640gsm) that is rigid enough to take thick applications of painting ground.

It is also possible to combine aggregates and abrasive powders into acrylic binding media. Indeed, many manufacturers offer ready-to-use pastel primer which involves the combination of pigment and abrasive into an acrylic binder to give a coloured pastel ground.

Sometimes, such combinations appear slightly glossy when compared to grounds prepared using rabbit glue or casein. However, one advantage of acrylic pastel grounds is their relative flexibility. This may mean that such grounds can be applied to stretched canvas supports, thereby enabling the artist to work on a larger scale.

Acrylic texture or modelling pastes are also manufactured, which may find use as grounds for pastel painting. Such pastes tend to be white, or off-white in colour and may be tinted by admixture with acrylic colour to give a coloured ground. Alternatively, the off-white paste can be applied to the support, then when dry overpainted with a thin glaze of acrylic colour. If the colour is applied too thickly, it may inhibit the abrasive nature of the texture paste.

Choice of Paper, When Hand-Preparing Pastel Grounds

Archival, acid-free papers are best suited as supports for pastel painting. The advantage of such papers is that they remain resilient when exposed to acid compounds and do not discolour readily, or decompose when exposed to mild damp. Such papers are often treated during manufacture with a calcium carbonate (chalk) buffer, which resists acids to an extent: it will prevent the paper from deteriorating in normal conditions (i.e. when not exposed to damp or humidity, or left in excessively acidic environments).

In terms of stability while painting with pastel, a durable, sturdy paper is preferred. For example, papers of 300gsm or above are suggested, as they do not cockle excessively if water is applied to them. By the same token, such papers have a degree of stability and firmness which may assist the application of pastel, where at times the paper surface is stressed by the pressure of the application. Watercolour papers are sold with a variety of surfaces. If one is applying a special ground (as outlined), it may be best to begin with a smooth (satin) surface watercolour paper of 300gsm weight or above. The smooth paper will provide a level surface on to which the pastel ground can be brushed. Consequently, the particles of pumice (or other abrasive) will stand up within the dried glue or casein film. Because the particles lie in this slightly exposed structure, the applied pastel pigment will catch on to this surface and the pigment dust will hold on, without the need to apply excessive coats of fixative.

The use of hand-prepared pastel grounds also allows the artist to experiment with a wide variety of papers, such as hand-made papers with rough deckle edges. In this way, the support can become an integral part of the painting itself.

Dralon Fibre as a Pastel Ground

Nylon dralon fibres, presented in the form of short, fluffy lengths can be mixed with a very dilute solution of acrylic binder (e.g. Primal AC 35), to give a synthetic version of the older Velour paper surface. The dralon fibres are carefully mixed into the dilute acrylic binder and then spread over the chosen paper surface. Upon drying, the fibres stick up and have a soft, velvety texture. If the surface is not dry/velvety enough, simply dilute the acrylic binder with more water and try again. To gain the optimum surface, the acrylic binder needs to be strong enough to bind the fibre, but not over strong, so that it creates a plastic surface.

Cork Particles

Dried, ground cork can be intermixed with rabbit glue (recipe as with pumice) to give a support for pastel painting. The resultant ground is slightly springy in nature but gently absorbent, where the pastel pigment dust is gently rubbed into the cork surface. If the surface is abraded too much when applying colour, the cork begins to disintegrate. As a consequence, cork offers a very sensitive (bark coloured) support.

Egg White (Glair) as Binding Agent for Pastel Grounds

Egg white hardens upon exposure to steam, to produce a water-insoluble binding. When pumice powder is incorporated into glair, a thin veil of this mixture can be applied to paper to give a pastel ground. The glair-pumice mixture is required to be applied freshly, then left to dry for perhaps 2-3 hours. After this time, the pastel painting is made on to the abrasive pumice ground. Immediately upon completion, the painting requires fixing with steam, so that the egg white hardens to a durable film. If the painting is not quickly fixed, it becomes impossible to harden the egg white and the surface becomes prone to attack from microbes.

Recipe for Egg White (Glair)

Take 3 egg whites
Put in food blender and whisk until foamy
Leave for 2-3 hours
Pour off liquid, throw away foam.

This procedure removes the non-adhesive component from the egg white, leaving the liquid portion, which is high in protein and adhesive strength. For pastel ground, the liquid portion is combined with the pumice powder and brushed out on to the paper surface.

After the ground has dried and the painting has been executed, the face of the painting is exposed to steam from a kettle. Due to this exposure to steam, the egg white hardens, trapping the pigment particles from behind and fixing the colour into the ground. Be careful not to add too much pumice into such a ground, as the colour of the pumice itself may show strongly once the painting is fixed. The egg white, when fixed, tends to deepen the colour values of the pastel pigment particles to a degree. This system overcomes the need to fix the painting by spray fixative.

Binding Agents for Pastel

A number of protein-type adhesives can be used for preparing soft pastel sticks. The degree of softness/hardness of a pastel stick is to some extent determined by the strength of the binding agent used, but these different binders inherently influence the relative hardness/softness of the pastel stick. For example, by tradition, the binder for soft pastels is often gum tragacanth. Pastels based on this binder tend to be very soft in nature, with a velvety mark. By contrast, pastels prepared using gum arabic tend to have a certain hardness. Water-swelling gums from small fruit trees, such as gum arabic, gum cherry and gum tragacanth are most commonly employed in the manufacture of pastels, although a number of other binders are often cited. For example, stale beer has a weak binding strength and may be used with many colours. In some modern pastel ranges, methylcellulose is used. This binder is of great importance, especially to the making of hand-prepared pastel sticks, because unlike natural binders it tends to keep for a period of months rather than days, before spoiling. A manufacturer may make use of all of these binding agents in order to create the optimum pastel stick for each pigment/colour offered.

It is also possible to make pastel sticks with some pigments without using any binding agent whatsoever. This is especially the case with clay-containing earth pigments, which may readily form into a solid stick just by mixture with water. Upon drying, the adhesive clay content of the pigment allows the pastel stick to remain in one piece.

Filler Material

Into manufactured pastels (and hand-made ones), a number of additives may be incorporated. For example, china clay (Pigment White 19, hydrated aluminium silicate) is often used to help impart softness to the pastel stick. The cohesive nature of china clay, when mixed with water, is also important: it helps to keep the pigment together in solid stick form, but gives way under gentle pressure, as the pastel stick contacts with the painting ground. The addition of filler material into any paint system is done judiciously: too much china clay for example will create a pastel stick that dries too hard and breaks easily. The exact amount of china clay used in each colour will vary, according to the degree of softness/hardness required. Kaolin is another form of china clay (normally whiter in colour), originally derived from China.

Talc (hydrous magnesium silicate) is also known as soapstone and French chalk. It may be used in some pastel sticks, where its soft nature can help produce a highly velvety mark. It is similar to china clay but tends to form more crumbly pastel sticks. As a consequence it is best used in very small quantities, perhaps along with china clay, to improve the softness of pastels derived from pigments with very small particle sizes (e.g. synthetic organic pigments).

Chalk, also known as whiting, is natural calcium carbonate (Pigment White 18). It has a harder, coarser nature than talc and china clay but is sometimes used in pastel making to give a harder, more durable pastel stick. Overuse of chalk may cause the pastel stick to become brittle, snapping when pressure is applied. Chalk works best when combined with earth pigments that naturally set when combined with water. The addition of a little chalk may help allow the particles to break up as they contact with the paper surface, so distributing colour to the painting ground.

Formation of Colour Ranges

Unlike paints based on liquid formulations, pastel relies on pigment applied in a dry form. As such, it is not easy to blend and mix colours on the painting surface. Some pastels are extra soft, so that some degree of blending can be achieved. However, the traditional method of working with pastel is to have each colour available in a series of pure tones, tints towards black and tints towards white. In the case of each manufacturer, this can vary and there is no set standard presentation of pastel colours.

In general terms, pastel ranges are organised in the following manner:

1. Pure Colour - where one pigment is represented.
2. Tints Towards White - where one colour is presented admixed with white to form a series of tints, moving towards white (pale, light tints). The choice of white used is crucial. Zinc white gives gentle gradations of the original colour, but adds a slightly cold tinge which becomes particularly apparent when the tint comprises white with just a trace of colour (very pale tints). By contrast, titanium white tends to give a deadening effect when admixed with colour, producing duller mixtures, where the white effect may be over strong.
3. Tints Towards Black - where one colour is presented admixed with black to form a series of tints, moving towards black (neutral, dark tints). Choice of black pigments is also crucial. Ideally, a neutral black (e.g. ivory black) is used, one that possesses a little transparency and therefore allows the original colour to have a presence in the mixture. This effect works best when both the black pigment and the colour being admixed are transparent in nature.

There are many variations on this format, but for practical reasons, this should suffice as an introduction.

Whenever two or more pigments are mixed, there is an inevitable loss of colour resonance. Also, admixtures are dependent upon particle size: pigments with larger particle size tend to dominate in mixtures.

Basic Recipes for Making Soft Pastels

The following recipes were prepared during the late spring in North Yorkshire, England, during a dry spell of weather. Each pastel stick took some 3-4 days to air-dry thoroughly when left in a dry room, without any central heating. It would be an advantage to prepare pastels during hot dry weather rather than at times of cold and damp. It is important to let pastels dry naturally: if too much heat is applied to the drying pastel sticks, they can split or crumble during the drying process. It also makes sense to prepare a batch of sticks at any one time, (perhaps six sticks of each colour) to save time and effort.

These recipes are intended to form a starting point for anyone interested in making their own soft pastels. It may be advisable to be prepared to change the recipe ingredients, in order to make the exact colour required (i.e. to add white to the core colour, etc).

Measurements : tbs = level tablespoon
tsp = level teaspoon

N.B. Tylose MH300 is a brand of methylcellulose.

Cadmium yellow lemon

Pigment:	cadmium yellow lemon	9 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

Cadmium yellow deep

Pigment:	cadmium yellow	9 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

Permanent yellow (hansa yellow)

Pigment:	permanent yellow	3 tbs
	zinc white	1 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

Cadmium orange

Pigment:	cadmium orange	4 tbs
	+ china clay	1 tsp
Binder: Tylose MH300	1:90	

Cadmium red medium

Pigment:	cadmium red	4 tbs
	+ china clay	1 tsp
Binder: Tylose MH300	1:90	

Permanent red PR 170 Neutral Red B

Pigment:	permanent red	3 tbs
	zinc white	1 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

Ultramarine blue deep

Pigment:	ultramarine blue deep	1 tbs
	+ china clay	4 tsp
Binder: Tylose MH300	1:60	

Cobalt turquoise light

Pigment:	cobalt turquoise light	3 tbs
	+ china clay	1 tsp
Binder: Tylose MH300	1:60	

Kings blue (mixed)

Pigment:	heliogen green	1 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

mixed with

Pigment:	titanium white	6 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:90	

Cinnabar green (mixed)

Pigment:	nickel titanium yellow	2 tbs
	+ china clay	1/2 tsp
Binder: Tylose MH300	1:90	

mixed with

Pigment:	chromium oxide green	1 tbs
	+ china clay	1/2 tsp
Binder: Tylose MH300	1:90	

Chromium oxide green

Pigment:	chromium oxide green	3 tbs
	+ china clay	1 tsp
Binder: Tylose MH300	1:90	

Olive green (mixed)

Pigment:	green earth, burnt	1 tbs
	+ china clay	1/2 tsp
Binder: Tylose MH300 1:90		

mixed with

Pigment:	chromium oxide green	1/2 tbs
	+ china clay	1/4 tsp
Binder: Tylose MH300	1:90	

Ivory black

Pigment:	ivory black	1 tbs
	+ china clay	1/2 tsp
Binder: Tylose MH300	1:60	

Silver graphite

Pigment:	silver graphite powder	3 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:30	

Mars yellow

Pigment:	iron oxide yellow	3 tbs
	+ china clay	7 tsp
Binder: water	+ a drop of Tylose MH300	
	1:90, to moisten	

Raw sienna

Pigment:	raw sienna	3 tbs
	+ china clay	4 tsp
Binder: water		

Burnt sienna

Pigment:	burnt sienna	4 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:90	

Burnt green earth

Pigment:	green earth, burnt	1 tbs
	+ china clay	1/2 tsp
Binder: water		

Venetian red

Pigment:	venetian red	3 tbs
	+ china clay	1 tsp
Binder: water		

Pozzuoli red

Pigment:	pozzuoli red	3 tbs
	+ china clay	1 tsp
Binder: water		

Caput mortuum

Pigment:	caput mortuum synthetic	4 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

Burnt umber

Pigment:	burnt umber	3 tbs
	+ china clay	1 tsp
Binder: water		

Davy's grey

Pigment:	davy's grey, grey-green	3 tbs
	+ china clay	1 tsp
Binder: Tylose MH300	1:60	

Iron oxide glimmer

Pigment:	iron oxide glimmer grey	10 tbs
	+ china clay	6 tsp
Binder: Tylose MH300	1:60	

Titanium white

Pigment:	titanium white	3 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:90	

Pearlescent pink – Use white pearlescent pigment, admixed with any transparent pigment, to create similar pearlescent tones. For pearlescent white, use a combination of equal parts zinc white/pearlescent white.

Pigment:	permanent red	3 tbs
	zinc white	1 tbs
	pearlescent white	1 tbs
	+ china clay	2 tsp
Binder: Tylose MH300	1:60	

Binding Agents

The binder, other than water for these recipes is methylcellulose, a converted starch glue, sold under the name "Tylose MH300". It dissolves completely in water and remains resoluble when made up into pastels, or when drawn marks are washed over with water. The dilute solutions suggested here make relatively soft pastels, when compared to those made with gum tragacanth or gum arabic.

Pastels made from the given recipes were prepared during the summer months. The temperature and humidity conditions at the time of making can greatly affect the amount of time you need to allow the pastel sticks to dry out before using. A little preservative (e.g. Preventol) added to the water used in manufacture may help to prevent pastel sticks from going mouldy. It is always a good idea to keep hand-made soft pastels away from damp conditions where mould can occur. When preparing the pastel sticks, always leave them to dry out thoroughly before use. If you put them close to a heat source whilst drying, this can sometimes make the sticks bend out of shape and split. It seems better to just leave them to dry out naturally, over a period of 1-2 days, or longer in colder, damp conditions.

Recipe for Stock Solution of Tylose MH300

Tylose MH300	1 part (i.e. 1 level teaspoon)
Water	60 parts

Add water to the powder and leave to stand for 1-2 days, until completely dissolved. Dilute the solution as required (e.g. 1 : 90), for weaker binding strength.

For some pigments, you need only use water to facilitate the formation of the stick.

Recipe for Stock Solution of Gum Tragacanth

Gum Tragacanth (powder)	1 part
Water	30 parts

Leave to soak for 1-2 days. The gum tragacanth powder will partially dissolve, leaving a thick residue. Sieve the liquid solution and throw away the residue. Dilute to give a weaker binding strength (e.g. 1:60, 1:90).

Gum tragacanth makes velvety soft pastels but the mixture quickly spoils without a preservative and, when compared to tylose, it is more fiddly to prepare.

Recipe for Stock Solution of Gum Arabic, or Gum Cherry

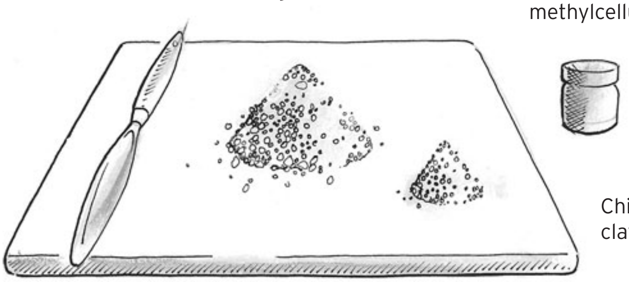
Gum arabic, or gum cherry	1 part
Water	30 parts

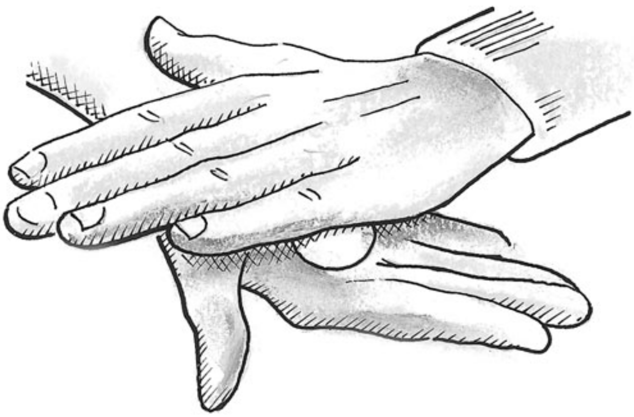
Gum arabic and gum cherry are supplied as translucent pieces, with an amber colour. Gum cherry is the harder of the two.

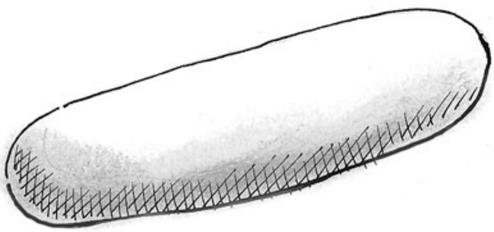
Place the required amount of dry gum into an empty glass jar. Boil a kettle. Pour the correct measure of boiling water over the gum and leave to stand for 1-2 days, until completely dissolved. Dilute the mixture as required, 1:60, 1:90, etc. With these harder binders, a weak solution will give a softer pastel.

Procedure for Hand-Making Soft Pastels

Before starting to prepare soft pastels by hand, ensure that you have the following list of materials (see page 392). It is especially important to wear disposable gloves and a dust mask when handling dry pigments. Check also that the pigments you intend to use are non-toxic, or that necessary precautions are taken when working with potentially toxic pigments.







Procedure for Hand-Making Soft Pastels

Checklist of materials:

- Empty jars
- Palette knives
- Slab
- Dust mask, gloves
- Recipes
- Pigments
- China clay
- Whiting
- Champagne chalk
- Tylose (methylcellulose), stock solutions of 1:30, 1:60, 1:90
- Gum tragacanth, gum arabic, or gum cherry stock solutions of 1:30, 1:60, 1:90
- Newspaper
- Paper towels
- Metal bowl
- Teaspoon
- Tablespoon

The recipes indicated cover a basic range of colours, there are hundreds of other pigments you could use. It is important to remember that the recipes are guidelines only: you may prefer to make harder or softer pastel sticks, in which case, the ingredients can be modified until you have the right texture for your work. When making pastels, it is worth making up perhaps three different strengths of binder for each colour. This will give three sticks of the same colour, all with different degrees of hardness/softness. By doing this, you can discover which recipe is right for your work.

It is usual to work on a large glass (or marble) slab and/or a large glass or metal bowl. The first step is to wet the pigment and make it into a paste with water only. Ideally distilled water is used, because it is pure but you could use a still mineral water, water from a boiled kettle which has cooled, or plain tap water and hope for the best.

To make the paste, measure out the desired amount of pigment and form into a cone on the slab, or in the bowl. Make a little depression in the top of the cone and pour on some water, enough simply to wet the pigment into a stiff paste. If you add too much water, then correct this by adding more pigment. If making a large quantity of colour, use a bowl for pre-mixing, as the water and pigment can be combined without flying everywhere. The pigment and water can be worked, until thoroughly combined, with a flexible palette knife. Some pigments can be difficult to wet. The synthetic organic pigments (e.g. phthalocyanine green) can be difficult to disperse into water. Try adding a drop of wetting agent, such as alcohol or ox-gall to the water.

To the pigment-water paste, add the recommended solution of tylose and china clay. The china clay usually soaks up the wetness, so that you are left with a dough-ball mixture, which can be readily rolled between the hands into a round ball, then subsequently into round pastel sticks. Wearing latex gloves is usually beneficial not just in terms of protection of the skin, but also to facilitate easy rolling of the pastel stick. Once the stick is formed it is carefully placed on to a sheet of absorbent paper (e.g. newspaper) and left to air-dry thoroughly before use. Leave at least one week between making and using the pastel, to ensure that all moisture has evaporated.

It is possible to add a small percentage of pumice powder (perhaps 10-15% of the total quantity of colour pigment) during the mixing stage. This creates a pastel stick that easily deposits colour on to the pastel support, especially when that support is also prepared with a toothy pumice surface, as already described. Adding too much pumice into the pastel stick will make it more likely to crumble: this system seems to work best when used with larger particle size pigments such as the earths.

Working with Pastels

Because the pigments used in pastel painting tend to become distributed into the environment of the space where the painting is made, it is very important to wear some protective clothing when working with pastels and to take some elementary steps to limit exposure to pigment dust. Manufactured pastel ranges tend to avoid any pigments that are considered to be toxic. For this reason, lead-based pigments as well as cadmium and cobalt pigments tend to be excluded.

First of all, it is imperative to wear protective gloves: this prevents pigment dust from becoming encrusted in nails and the flesh of the hands. Secondly, a dust mask should be worn, to prevent inhalation of pigment dust. Thirdly, it is wise to dampen the air in the studio prior to working. This can be done by applying water from a plant sprayer into the air, every 15-30 minutes. This dampens the air and causes any airborne dust to fall quickly to floor level. Ensure that the floor is washed after each painting session, to remove pigment dust. Better still, have a vacuum cleaner on hand to remove dusts periodically. If one insists on applying the pastel without wearing gloves, then at least use a barrier cream on the hands, wrists and forearms to prevent prolonged contact with pigment dust.

After use, store pastels in a closed box, to contain dust. If the sticks get dirty during use, they can be cleaned by placing into a Tupperware box full of dry rice which is then shaken so that the rice takes off the dirty top layer of pigment dust.

While working, the pastel sticks can be laid out in colour sequence on a worktop. This will allow the artist to pick and choose tints of colour as required. It makes sense to order the colours into pure tone, tints towards black, tints towards white and so on, so that each colour is readily available as required.

Manipulating Pastel

During the painting process, colour is normally applied to the painting support by holding the pastel stick between thumb and forefinger. Pastels are sold in a variety of stick formats. Sometimes they are offered in the form of thin cigarette sticks (5mm), but are also available as thicker sticks (10mm) and even fat sticks (20-30mm). The thickness of the stick governs the type of mark expressed. In French pastel painting, the tradition is to use fine, thin sticks. By contrast, in recent years in Britain and North America, artists have preferred to work with fatter sticks, which show a more expressive mark. Fashions change, but all that matters to the artist is that the pastel stick chosen deposits colour evenly on to the paint support. With some brands, the pastel stick is formatted to work with a specific type of painting support, usually manufactured by the same company. This is especially the case with some harder pastels, which only work on very toothy supports.

With some pastel brands, the applied colour can be further worked into by adding water to the painting. When the binder is readily resoluble (e.g. methylcellulose) this is more than possible. By keeping a solution of methylcellulose at hand, this can be used to re-work passages of the painting. Although this changes the pastel from a dry form of painting to a liquid one, the methylcellulose solution dries back to a similar matt film to that of the applied pastel stick.

Fixing and Storage of Pastel Paintings

Another method of manipulating applied colour is to work into the surface with soft brushes, such as those made with squirrel or ox hair. These brushes (often referred to as "mop" brushes) are soft enough to re-distribute or blend the pastel pigment particles, without scrubbing them from the surface. Special wound and bound paper blending tools, known as "torchons" can also be used to soften the effect of applied colour. This is especially useful when portrait painting, where pale tints need to be blended and fused into each other. These torchons (also known as "paper stumps") can be firmly applied to the pigment particles without completely erasing the colour from the surface. It is useful to use such implements to gain a varied finish to the painting. Similarly, putty rubbers/erasers can be used to soften lines, although they may leave a greasy mark or residue on the painting surface. A piece of fine sandpaper may also be useful to sand away part of the paint surface if a course ground, such as those made with pumice or quartz chips, has been used.

Multiple layers of pastel can be applied, but this is very dependent upon the type of ground used. A toothy support will provide a better key for multiple applications than smoother surfaces, allowing more pigment dust to be despatched on to the painting surface.

As already noted, fixing of pastel paintings is a cause of concern. Various formulations are available for this purpose. Perhaps the best solution is not to fix at all, but instead to prepare the pastel ground carefully so that good amounts of pigment dust can attach to the ground without the need of fixing. The process of steam fixing with egg white is another possibility, but as this needs to be done soon after completion of the painting, it may not suit some working methods (e.g. if one keeps on painting over a period of months).

Careful and skilful application of spray fixatives can also be effective, but overuse of such fixatives can lead to saturation of the paint surface and possible discoloration over time. Modern aerosol fixatives are based on solutions of synthetic resins (e.g. Paraloid B-72, a light and age-resistant type of acrylic resin) which dry to a neutral finish when applied to pastel pigment dust. If such fixatives are overused, the resin begins to build up a saturated effect, thereby slightly altering colouring relationships. The key to this problem is careful and judicious applications of spray fixative. Following the manufacturers' recommendations, the fixative is sprayed at a set distance from the picture surface in an even and consistent manner. Avoid using heavy applications, for example after the painting is finished, where the whole picture is saturated with a large dose of fixative. It is far more successful to apply very thin layers of fix as each application of pastel is put down. In this manner, any colour shift can be seen during the period of painting and subsequent layers of pastel laid down with this in mind.

Fixatives based on alcohol-based resin varnishes such as sandarac or shellac may be less successful in that they darken with age and can crack when applied in multiple layers or with any thickness. Such liquid varnishes need to be applied with an atomiser or hand-held spray-diffuser and inevitably leave less consistent fixative layers than aerosol fixatives.

Finished pastel paintings can be shown under glass (glazed), or stored in closed portfolios. When storing, interleave each painting (on paper) with sheets of acid-free tissue paper, or glassine paper (a coated translucent paper which resists picking up pastel pigment dust). Any pressure applied to pastel paintings may cause the surface to become disturbed. As a consequence, stored paintings need to be kept carefully, away from wind sources and need to be handled with clean hands, as any greasy residue will transfer into the matt, dry paint surface.

It is imperative to paint using pigments that are stable to light and air. For this reason, lead-based colours are never used for pastel painting, as they tend to darken upon exposure to air. Similarly, colours that are fugitive to light should be avoided, because the particles of pigment are not bound and as such lie exposed on the painting support and are therefore liable to fading upon exposure.

Acrylic Painting

Acrylic Paint Systems

Acrylic paint is based on an emulsion of synthetic resins, suspended in water. Although the term “synthetic resin” is often used, acrylic resin is based on natural materials which have been chemically altered by means of modern technology, into a new type of raw material. This new basic material, acrylic resin, is presented for ease of use, in the form of clear beads or droplets. It is the basis for a number of “plastic” products, including Plexiglas (synthetic glass) and has many uses in industry. To make a binding agent for paints, the acrylic resin has to be made into a fluid solution. This is achieved by the polymerisation of acrylic and methacrylic acid, to form a milky solution, which dries perfectly clear. This product is referred to as an acrylic emulsion, or acrylic dispersion. The first acrylic products were developed in Germany during the 1920s and ’30s: the first artists’ acrylic paints (based on water-borne acrylic emulsion) became available in the 1950s and have been subsequently updated and improved up to the present day.

The first acrylic paints for artists were actually based on a solution of the acrylic resin (polybutyl methacrylate, under the trade name “Acryloid F-10”) into turpentine, by the American company, Bocur, in the early 1940s. The paint was sold under the brand name “Magna”. Both Leonard Bocur and Sam Golden, who co-produced this early type of acrylic paint, had strong links with many leading artists working in New York in the late 1940s. Together, they ran a store for artists’ colours, which was frequented by artists such as De Kooning, Newman, Louis, Noland, Lichtenstein and Rothko.

Magna was developed in conjunction with Rhom and Haas, manufacturers of raw acrylic resins, to provide a paint that had a degree of viscosity before dilution, but upon dilution could be painted out in flat, even applications. The dilution of the paint with turpentine or mineral spirit was a key element with Magna: the paint could be diluted in this manner yet retain high colour resonance. This was in part due to the high pigment concentration of these early acrylics, but also to the rheological properties of the paint binder itself.

Because the acrylic resin was dissolved into turpentine, the dried paint layer remained re-soluble with turpentine or mineral spirit upon drying. This meant that the application of multiple layers of paint became difficult, because the top layer would soften the previous one, making it sticky and giving the possibility of the applied layers blending or fusing together. As a consequence of this, Bocur developed a special isolating varnish that was resistant to turpentine or mineral spirit. This system proved useful for artists working in a planned manner, but was less useful to those wishing to paint in a spontaneous fashion.

Magna is no longer manufactured, but other companies who specialise in acrylic paint systems continue to offer similar systems. For general use, these acrylic-solvent paint systems have a substantial drawback with regards to health and safety for the user, and adequate ventilation is required when working with such products. The use of acrylic resins into solvent has also been widely employed in conservation programmes, where the clarity of film provided and resistance to discoloration of acrylic resin films are highly regarded.

How Acrylic Paint Works

The acrylic dispersion is not soluble with water, but the addition of surfactants emulsifies the mixture of acrylic and water, so that it can be painted out and further diluted with water. The paint dries by evaporation of the water constituent. In turn, as the water evaporates into the atmosphere, capillary action forces the water out and the acrylic polymers bond together. As the water content is reduced, so the polymers form a regular, hexagonal pattern, trapping the pigment (colour) particles and producing a clear, flexible and durable dry paint film.

In their wet state, acrylic paints are a little lighter (milky in appearance) than when dry. This means that there is a subtle colour shift from wet paint to dry paint. This is because the acrylic emulsion is a milky-white colour when wet but dries to become completely clear. It takes a little time to get used to this process. It is probably best at this stage to think of acrylic as a paint system in its own right and not to compare it unfairly with oil paint. Because oil paint remains virtually unchanged in terms of gloss and colour depth, from wet to dry, it is tempting to argue that acrylic paint is inferior, because the artist has to compensate for the slight colour shift upon drying. Balance this advantage of oil paint with the advantages of acrylic paint:

Oil Paint

Colour remains constant upon drying

Long drying time

Risk of cracking and wrinkling of paint film

Long term: oil paint becomes brittle, harder

Long term: oil paint yellows / darkens

Long term: oil paint becomes more transparent with age

Dilution: solvents such as turpentine and white spirit, which may be uncomfortable for user

Acrylic Paint

Very quick drying time, subsequent coats can be applied speedily without fear of cracking

Paint film remains very flexible, regardless of thickness of application

Long term: acrylic paint remains flexible

Long term: acrylic paint does not yellow or darken

Long term: acrylic paint does not become transparent with age, remains constant

Dilution: water, non-hazardous

Upon drying the paint film becomes water-insoluble. The drying process is relatively quick compared to oil colours: a thin layer of acrylic paint will dry in just a few moments. The true curing (complete drying) time is a little longer but usually, acrylic paint can be overpainted as soon as it is surface dry, without fear of cracking. This represents enormous advantages to the artist when compared to the perilous nature of oil paints, where cracking can occur at any time.

Another great advantage for the user, is that acrylic paints are thinned only with water, or extended with a combination of water and paint medium. No potentially harmful solvents are involved. This is a great advantage, particularly for artists working outdoors, or those working in a confined space.

Acrylic Paints

Acrylic paints are available in a variety of formats, which can represent different consistencies and/or qualities. The acrylic emulsion or dispersion (the basic binder for the paint) is presented as a fluid, milky solution. There are many different types of acrylic resin suitable for making artists' paints. In manufactured paint ranges, often these basic acrylic resins are modified - with flow agents, matting agents, stabilising agents, etc - to assist the overall working properties of the paint paste. In the case of the best quality acrylic colours, the basic resin may be modified with a great number of additives, the sum of which combine to produce a paint paste with characteristic properties. For example, some brands dry to show a satin-matt sheen, whereas other brands may dry with minimal colour shift, from wet to dry: these facets are governed by the type of resin(s) used and their formulation with various additive materials.

One consequence of the high number of component materials normally incorporated in artists' acrylic paints is that hand-made acrylic colour is somewhat lacking in finesse. By contrast to hand-mixed oil colours, acrylic colours tend to be very variable in consistency and film sheen when prepared by hand. Without the close calculations of additives used by manufacturers of acrylic paint, the individual artist is somewhat at the mercy of the properties of the acrylic resin binder chosen. However, if the paint is prepared by hand and used within a short space of time, reasonable results can be achieved. This is especially so, if one considers the comparative working properties of the different acrylic binders available and adjusts the paint making process in accordance with those properties. For example, each different resin possesses a different amount of solid resin, when presented in dispersion/emulsion form with water. In the following list of commonly available resins (in water-borne dispersion/emulsion form), the solid resin content is indicated by the letters FK. If the solids content is high, it follows that the resultant paint paste will include a smaller amount of water, which upon evaporation tends to cause less shrinkage of the paint film than would be the case with high-water content acrylic resin dispersions. As a consequence, such dispersions, which typically make a short, stiff paint paste, are more often applicable to making paint where a degree of impasto is required. It follows that dispersions with a higher water content are better suited to making paints intended to be used brushed flat into glazes.

Typical Acrylic Resin Dispersions and Their Basic Characteristics

This is by no means a comprehensive list: indeed, the specification and availability of these dispersions is always in flux. These are types of dispersion that are commonly available in Western Europe.

(MFT= minimum temperature required to form a coherent paint film*)
(FK= solids content)

* Acrylic paints need to be protected from frost

Primal AC 35	MFT 9°C	FK 46.5%

High binding power, tough, durable. Fluid, milky consistency

Dispersion K6 Gloss	MFT 11°C	FK 60.5%

Glossy, very hard finish, very durable, elastic

Dispersion K6 Matt	MFT 8°C	FK 60%

Matt, slightly milky dispersion

Plextol B-500	MFT 7°C	FK 49-50%
Good pigment binder for acrylic paints, low-tack		
Plextol D-498	MFT 5°C	FK not available
Clear, medium gloss. Thicker consistency than that of Primal AC 35		

All these acrylic dispersions have different qualities. Upon drying, some are soft, some hard, some are more glossy, others less so. The manufacturer takes the raw acrylic polymer emulsion and adds various agents to aid its flow and brushing qualities; prevent it from spoiling; prevent it from freezing in cold climates.

Hand-Preparation of Acrylic Paints

There are many ways to prepare acrylic paints by hand and each supplier of the raw materials required may be able to supply recipe information. The processes outlined represent the simplest way to prepare colour into paint form. It is intended that these simple paint pastes are prepared and then used within one painting session, rather than stored for a longer period. Storage is difficult, because the raw materials may separate or coagulate upon standing, leaving a paint with a poor viscosity.

A supply of clean plastic pots or air-tight glass jars is useful to place the prepared paint paste into. It is usually better practice to prepare a milky, semi-fluid paint paste than one that is free flowing or extremely stiff in nature.

Suggested Basic Palette for Acrylic Paint Making

The following pigments can be assumed to be non-hazardous and relatively easy to prepare. Where a pigment may require a wetting agent, an asterix * denotes this. If possible, try to obtain these colours already dispersed in water (colour pastes).

Titanium white	PW 4
Cadmium lemon	PY 35

Zinc white †	PW6
Hansa yellow*	PY 74
Yellow iron oxide	PY 42
Nickel titanium yellow	PY 53
Intensive yellow	N/A
Cadmium orange	PO 20
Transparent orange-red oxide	PR 102
Permanent red*	PR 170
Paliogen maroon*	PR 179
Caput mortuum (violet iron oxide)	PR 42
Phthalocyanine blue*	PB 15
Ultramarine blue	PB 29
Chrome oxide green	PG 17
Irgazine yellow (green shade)*	PG 129
Iron oxide black	PBlk 11

† – Zinc white is not stable in acrylic dispersions for use on outdoor murals, where the paint film may break down and chalk. It is common practice among acrylic paint manufacturers to prepare zinc white with an addition of titanium white (perhaps 15-20%) to help stabilise the paint mixture.

The following basic procedure can be followed to make such a paint:

Prepare dry pigment with distilled water, in a paste, which should be stiff. Each particle of pigment is required to be wet before incorporation with the chosen binder. In some cases, this cannot be done by simply mixing water and pigment together. An addition of wetting agent (e.g. disponil or orotan, in the ratios indicated, see Additives for Acrylic Paint Systems) may be required with some pigments, especially the synthetic organic ones. It may be advisable to purchase the synthetic organic pigments in the form of ready-dispersed water-pigment pastes. These pastes contain a biocide to prevent spoiling and a flow agent to assist brushing, and provide a ready-to-use colour paste to add to the acrylic dispersion binder.

The stiff pigment-water paste needs to be thoroughly mixed before incorporation with the acrylic dispersion binder. In the first place, the dry pigment and water are brought together on a ground glass slab, using a flat, long bladed palette knife. Once all the pigment is absorbed into the water to form a wet paste, this needs to be mulled, with a glass muller, using a figure of eight motion (as would be the case with oil colour). This process helps to divide the pigment particles from each other and encourage saturation by the water. The longer this is done, the smoother the end paint paste should be. If the water dries off during this process, add a tiny bit more to re-wet. It is best to keep a supply of distilled water nearby, in a dispenser bottle, so that small droplets can be added if and when the pigment-water paste becomes too dry. To the stiffish water-pigment paste, a small addition of Mowiol 4-98 (up to 10%) is slowly added to gain a slightly smoother, richer wet paste. This resoluble acrylic resin helps to stabilise the consistency of the paste but has minimal binding power. It is possible to make a very simple resoluble paint using mowiol as the binding agent, although the dried paint film will remain water-soluble indefinitely. It is preferable to use mowiol as an additive rather than a binding agent. Into the water-pigment-mowiol paste, a small amount of a filler material may be added to provide a shorter (stiffer) consistency. For this purpose, aluminium hydrate can be combined with pigments which show transparency, whereas for opaque pigments, blanc fix is used. Overuse of such filler will make an unstable paint film and may cause cracking. No more than 5-10% filler is normally required to provide optimum results.

To the resultant paste, the binder is added to create a paint that will dry to form a cohesive, insoluble film. The choice of binder, as already indicated, depends on the intended use. For example, to create a flowing, easy to brush-out paint, an acrylic resin dispersion with a low solids content is selected. The dried sheen of the chosen binder may also be of consequence. Some dispersions are offered which already contain a matting agent, thereby producing satin-matt effects upon drying. Otherwise, special matting agents can be added to the dispersion (e.g. aerosil, a fine white powder that imparts mattness, or fine scotchlite, very small hollow plastic bubbles) to give a more matt sheen. Some experimentation is called for: it would be wise to paint out a number of different acrylic resin dispersions (without pigmentation) on to a sheet of clean glass, and leave them to dry. Upon drying, one can gauge the relative gloss/mattness of the paint film, its transparency and whether or not it cracks or wrinkles upon drying. Sometimes, if too much water is added to an acrylic dispersion, it may dry unevenly - in the worst case, forming some kind of cracks or splits. The addition of a matting agent to an acrylic dispersion will lead to a loss of transparency and in some cases may cause the acrylic to have a slight yellow appearance. One can see that with acrylic paint making, the smallest thing can upset the balance of the paint paste.

The exact quantity of acrylic resin dispersion to pigment (+ other additives) needs to be judged on a pigment-to-pigment basis. Some pigments will need a larger quantity of binder than others. In general, those with a larger particle size will require more binder than those of a very fine particle size. However, again experimentation is required prior to application on to the painting surface. It should also be borne in mind that the drying time of each paint layer may be variable, compared with manufactured paints, especially when the original paint paste is diluted with extra water. Some care should be exercised when painting: for example, leave each layer to dry off before overpainting.

The hand-preparation of pigment into an acrylic resin dispersion allows the artist to judge the intensity of the resultant paint. It also enables them to prepare colours that are not normally available in acrylic paint ranges. For example, it is difficult for manufacturers to use earth pigments in their colour ranges, because these tend to include impurities, may have a degree of grittiness and irregular particle size. In particular, the particle size, and the way it reacts to water can make paint making nigh on impossible in terms of a commercial acrylic paint. Some earth pigments swell when in contact with water, and will only form a stable mixture when gently coaxed by hand-mixing. As a result, the use of these pigments is omitted by most acrylic paint manufacturers. However, with care, they can be used to make simple hand-made paints, which are prepared and then applied immediately. Once dry, the applied paint will quickly show if it has enough binding power. If the resultant paint application is too matt, simply add more binder; if it is underbound and delaminating from the support, again add more binder. A slightly thickened acrylic resin dispersion may also assist in this regard. In such cases, the original acrylic resin dispersion is thickened mildly (i.e. not as much as when making an impasto gel). The resultant fat dispersion will help to adhere larger particles to the support. This can also be useful when working with other large particle dry colours or additives such as mica flakes, silver glitter, marble dusts and chips, coloured ground glass and with crystalline mineral pigments such as azurite and malachite. In fact any dry material that does not readily make a simple paint paste will benefit from being prepared in this way.

Additives for Acrylic Paint Systems

When using dry pigments to make acrylic paints, the following additives may be useful. They are all commonly in use in Western Europe, but their specification/properties are always in flux, due to developments within the paint and coatings industry, for which they are formulated. Exact use of these additives may depend on the context and type of work undertaken. Check with the supplier for further details.

Disponil 286 (Wetting Agent)

When making acrylic paints from dry pigment, add 0.5% disponil to the water used to make the pigment paste. This synthetic wetting agent helps to saturate the pigment particles, making it easier for the binder (e.g. Plextol D-498) to combine readily, to make a smooth paint paste. Some acrylic binders may already contain similar wetting / flow agents: check with the supplier.

Orotan 731 K (Dispersing Agent)

To acrylic paint paste, add 1% orotan, to facilitate easy brushing/flow of paint.

Mowiol 4 - 98 (Stabilising Agent)

Add 10% mowiol to acrylic paint paste to stabilise the consistency (so that contents do not settle out) and slightly retard the drying time of the paint film. Over use of this additive may leave the paint film resoluble/prone to swelling when in contact with water.

Preservative

It is not recommended to add a preservative agent to hand-made acrylic paint systems. Such preservatives (e.g. sodium-2-phenylphenolate) tend to be harmful to the environment when released into the water supply and are toxic to use. In any case, it is better practice to make and use hand-made acrylic paints, so that the contents do not separate, or become unworkable after standing for a prolonged period. If only distilled water is added to paint mixtures, this may help to alleviate mould growth. Manufactured paints may already contain a biocide as preservative. However, it is vital that water is not stirred back into manufactured paints and left to stand, as it invariably attracts microbes and starts to smell or become infected with mould.

Thickener for Acrylic Paint Systems (e.g. Rohagit SD 15)

When added in very small quantities (no more than 10%) to acrylic paint pastes, or directly into acrylic binder, this thickening agent causes swelling. By careful addition of thickener, acrylic gels can be made. However, even with careful notation of the amounts used, it is difficult to repeat this process so that each time a consistent gel is created.

Using these additives to make acrylic paints may lead to a further understanding of the complexities involved in the manufacture of acrylic paint systems. Proprietary brands either already contain similar additives, or such additives are available separately and can be used to further modify the manufactured brand (e.g. impasto gel to create thicker passages).

Dry Additives Materials

Because acrylic is such a good adhesive, many dry materials can be experimented with to achieve texture, change of sheen, etc. For example, any inert filler can be incorporated to give more bulk and/or texture to the paint paste. Marble, quartz, basalt, granite in grit or sand form could be utilised. Before use, apply the mix of dry material with the chosen binder on to a sheet of glass and judge how well it dries. It follows that incorporation into a thick gel impasto will be more successful, where the large particles of the additive(s) are dispersed into a viscous, fat paste of acrylic. This could be done by incorporation into a manufactured acrylic impasto gel, or by thickening a basic acrylic resin dispersion, as already indicated.

Glass Beads

Glass beads in a variety of sizes, from 0.5mm diameter upwards are available and can be incorporated into acrylic dispersions. While such inclusions create some texture/granulation on the surface of the painting, they also act to encourage light refraction. In effect, light is bounced around between the pigment content and the glass beads, causing a more brilliant effect. This is especially useful with fluorescent colours and with the synthetic organic pigments, in both cases, exaggerated luminosity results.

Scotchlite - Hollow Plastic Bubbles

Can be used in very small additions, to increase matting of the paint film. In larger quantities, it can be useful in creating lightweight texture pastes when combined with acrylic resin dispersion with a high solids content. However, thorough mixing is imperative in such combinations to ensure no dry materials are left unbound. It is best to do this by combining the plastic bubbles and acrylic dispersion in some kind of food blending machine, to create a thorough mixing. However, the apparatus must obviously never be used for food preparation again!

Health and Safety Information

Acrylic paints are water-based emulsions. Clean-up is with water. For general use, there are no specific hazards involved. However, some pigments used in the manufacture of acrylic paints are labelled as not suitable for spray-applying (e.g. cadmium pigments), to conform to US/EU labelling requirements. Also, some additives to acrylic paints may be hazardous when used in large quantities, when spilled, etc. Check with the supplier on the nature and properties of each component material prior to commencing paint making. Some acrylic dispersions (and acrylic paints) may contain very small solvent additives, to speed drying/evaporation.

Dust Masks

All pigments in dry powder form can be assumed to be nuisance dusts. As a consequence, while working with dry powders, appropriate dust masks should be worn. The exact specifications for dust masks change according to new research. Within the EU, protective dust masks are accorded a P rating, which relates to their suitability to specific tasks. For example, masks P1, P2 and P3, may be adequate for use with small amounts of nuisance dusts. Always check with the supplier and read product information, before using in a given situation. Remember that a mask designed for use with dry powders may not be suitable for use with wet applications (e.g. spraying paint). The information relating to choice of dust mask is in constant flux and it would unwise to recommend a specific mask for a specific situation. The dust mask manufacturer may be able to recommend the most suitable one for a particular purpose.

Gloves

Protective gloves are appropriate when working with dry powders. Caution is advised when choosing these items. Some gloves (e.g. latex type) may cause a skin reaction for some people. The manufacturer of the equipment should be able to provide up-to-date information.

Manufactured Acrylic Paints

It is good policy to use only one brand of acrylic paint. Try to avoid intermixing of brands and mediums. This is because each brand may use slightly different resins, or even if the same acrylic resin is used, it could be modified to a different consistency. In the worst case scenario, intermixing can lead to differing drying rates and rates of flexibility in the paint film. Acrylic paint manufactures can opt to make any of the following types of paint:

1. A fluid paint (i.e. same consistency as the raw acrylic polymer emulsion).
2. A gel paint, with a thick buttery paste consistency, similar to that of oil paint.
3. A modified fluid paint (can be thinner, as with acrylic "inks").

In order to make a fluid acrylic paint, the manufacturer simply mixes the pigment into the binder. To provide the best possible paint (i.e. where the pigment is evenly distributed into the binding medium), the mixture is put through a triple roll mill. Often, the mixture is re-milled and sometimes sieved to remove any lumps, etc. This process may be different for different colours, depending on the nature of the pigments used.

Many acrylic paint ranges employ the synthetic organic pigments, which may be bought by the manufacturer in the form of wet pastes. These pastes, or pigment dispersions may reduce the need for milling (mixing) with the binder, therefore reducing the overall cost of production.

To make a gel consistency paint, the acrylic polymer emulsion has to be made fat by the addition of a thickening agent. The emulsion and pigment may already be mixed together, before the thickening takes place. The resultant paint is short in consistency (meaning that when manipulated with a brush or palette knife, the paint does not spread out, unless diluted with medium or water). It has a thick, buttery-paste consistency, ideal for application by painting knife or short dabbings with a brush. The thick consistency allows for an impasto technique, to build relief and texture. Because the manufacturing process takes a little longer than with fluid colours, so the cost of the product may be higher. Generally, artists' quality acrylics are presented in this thick gel-form. This probably has more to do with the notion that acrylic paint should feel like oil paint. It does not mean that all fluid form acrylics are inferior: indeed, the fluid acrylics are closer to the raw material than the mechanically thickened gel-type acrylics. Some ranges are marketed as artists' quality paints, even though they have a fluid, flow formula.

Sometimes, the acrylic polymer emulsion is further modified by dilution so that it has a consistency which is even more fluid, so that when colour is introduced, an ink-like paint is produced.

Modified Paint Ranges

There are many different types of acrylic paint on the market and it is impossible to describe them all here. True artists' quality acrylics contain good pigment, finely dispersed into a high quality acrylic polymer elusion binder. Extenders, or rather "carriers" may be employed, so that the resultant paint brushes out evenly. The exact use of extender, or filler material can help to produce paint with a high chroma; overuse of them can lead to duller colour values and a weaker paint film. Some colour ranges contain maximum pigment content to acrylic resin, with no extender at all. In theory, this gives a paint with maximum tinting strength: in practice, each colour in the range has a slightly different finish. Some pigments require more binding medium than others, with the result that the paint film is either saturated (glossy), or matt (dull) in appearance. This system provides the artist with strong colour: the finish can be further manipulated by the addition of gloss or matt mediums for coherence. Alternatively, the finished painting can simply be given a unifying coat of varnish.

Acrylic Painting Mediums

A huge variety of mediums is available for acrylic paint. The addition of a medium can be used to change the surface finish or texture, or both. Similarly, there is an ever-increasing number of primers and painting grounds, so that the initial painting support can be made absorbent, semi-absorbent, glossy, textured, etc. All these products provide an expanding range of possibilities for the acrylic painter.

Mediums and varnishes can be loosely divided into the following formats:

1. Fluid medium, available in matt, gloss and satin finishes. Used in place of, or in conjunction with water, to thin/extend colour. Using

a medium instead of water to dilute acrylic paint will give a more consistent paint finish. Sometimes, if water is used to dilute, the paint can dry too matt, or uneven in areas of matt and gloss. The matt mediums tend to be slightly cloudy upon drying; gloss mediums dry water-clear.

2. Gel medium, thick impasto pastes, available in gloss or matt. Mix together for a satin finish. These fat pastes are mixed with colour to build impasto and remain flexible upon drying. The matt mediums tend to be slightly cloudy upon drying, giving an appearance a little like wax. By contrast, good quality gloss mediums will appear clear when dry. The addition of gloss gel to acrylic paint tends to produce a very heavy glossiness. Although these gels are designed to help impart impasto to the paint surface, as with any material they have their limitations. Impasto is best built up by applying multiple layers of gel, rather than one thick wodge. Over-thick applications of gel may dry to show some shrinkage as the water content evaporates. In the worst cases, this leads to a great loss of volume in the paint film (the gel when first applied appears as a high impasto but on drying levels down). During this drying out process, it is possible that the gel will split or shrivel, so compromising the paint film.

For each manufacturer's product, the extreme of impasto capable by their gel will differ. Some companies produce gels with a very high solids content which hold better when applied thickly. However, such gels may cause applications on to stretched canvas to sag considerably. It may therefore be advisable to apply such gels on to rigid supports only. Normal practice is to tint the gel with a quantity of colour before application. This is best done by thorough mixing in a plastic cup, using a plastic palette knife, gradually adding the required colour concentration into the gel. Once mixed thoroughly, the gel can be applied, by brushing, palette or painting knife, fingers, spatulas, sponge, etc. When applied to a thickness of about 3cm, most gels will dry without undue shrinkage. Over the dried layer of gel, further applications can be made of a similar thickness. However, it is vital to wait for each layer to dry thoroughly before proceeding. It is likely that such layered applications of paint and gel will create a paint film that becomes progressively more inflexible. Again, some testing is advisable before use in permanent artworks.

The variety of gels available may appear confusing at first to most artists. It is vital when working with a brand of paint, to stick with gels that are formulated for use with that specific brand. Most companies now offer information sheets or charts indicating when and where a gel can be used to best advantage. For example, some gels have a high gloss sheen, while others may be self-levelling. It is normal to presume that acrylic colour can be mixed into a gel in any ratio (unlike oil paint mediums, where a maximum of 10% medium to paint is advised), although reference to manufacturers' information may give clearer guidelines. By adding colour into gel, a large volume of paint can be achieved. Although this gel-paint will be weaker in colour strength (according to the amount of paint added), it may be a useful shortcut, when working on a large scale.

Hand-made gel (i.e. acrylic dispersions, plus thickening agent) should be used with great caution. They should work well with hand-made paint formulations that are based on the same acrylic resin dispersion as that which has been thickened, but may not work well with brand acrylic paints, due to differing formulations. In the worst case, admixtures of different brands and/or hand-made paint/medium may cause blistering, cracking or non-film formation. Intermixed brands, or brand paint plus hand-made paint may also begin to smell when the component parts are not compatible.

3. Texture pastes can be added to colour, or used in conjunction with primer. These are often based on mixtures of acrylic with quartz, marble dust, or synthetic materials such as dralon fibres, or scotchlite (hollow plastic bubbles). All should remain flexible and can be mixed into paint, or laid down on top of the dried priming coat, to give a textured ground. Some texture pastes may reduce the flexibility of the paint film. Some can be mixed with primer/gesso, to give a gently toothed or absorbent surface. The texture pastes tend to show some colour when dry (usually an off white), which should be borne in mind when mixing with colour. Texture or "moulding" pastes tend to dry with less shrinkage than is the case with gels, due to a lower water content. Also, the composition may include inert fillers such as quartz or marble dust, which help create great stability. However, flexibility is an issue with these pastes, especially when they are applied very thickly. Best practice is to build impasto slowly by adding layers of texture paste (perhaps 3cm thick) and waiting for each layer to dry before proceeding with the

next. Many oil painters have used these texture moulding pastes to create an impasto underpainting (in acrylic), which when dry can be safely overpainted with oil colours. While such pastes tend to have reduced absorbency compared with acrylic gesso, they normally have enough texture to allow oil-based paints to grip to the surface adequately.

4. Varnishes are available for acrylics in two distinct formats:

i) Water-thinnable varnish, which can be mixed with the paint to give a harder finish (scratch-proof), or as a final coating, to change, or homogenise the appearance of the final paint layers. The gloss varieties of these varnishes tend to dry to give a clear coating. The matt or satin varieties may slightly frost the surface of the painting, so altering the sheen appearance: in some cases this may mean that delicate parts of the painting are obscured. When brushing these varnishes, care should be taken to avoid the inclusion of air bubbles into the varnish film. This is because the varnish dries so quickly that any air bubbles will tend to form and dry before they can be brushed out. An addition of water (perhaps 20%) may help to keep the varnish wet on the surface while being brushed out. With some water-based acrylic varnishes, dilution with water is always necessary because the neat varnish is too thick to brush out successfully. Testing is wise in such instances, to gauge the brushing properties of the chosen varnish. Use soft hog hair varnish brushes, with gently shaped tips (rather than cut tips), working the applied varnish in one direction across the painting surface. It should be possible to brush out any residual hairs or other impurities while the varnish is still wet, by changing direction of stroke. The exact brushing technique for varnish application will vary according to the type of finish required.

Because these water-based varnishes dry to become insoluble, they are very difficult for conservators to remove when cleaning or repairing a painting, without damaging the paint surface. As a consequence, it is recommended that such varnishes are used to enhance the sheen of the final layers of the painting, i.e. colour is worked into the varnish to apply coloured glazes which will impart a matt/satin or gloss sheen to the painting surface. If varnish needs to be applied to the dried painting in order to protect the surface, or merely to change the sheen of the finished painting, it may be more appropriate to apply a solvent-based varnish, which can be removed without damaging the paint surface.

ii) Solvent-based varnishes are only ever used over dried acrylic paint. A final protective coat of varnish can be applied to dried acrylic paintings with such varnishes. These varnishes are formed by solving acrylic resin (sometimes a combination of resin types) into an active high polar solvent (e.g. toluene, benzene, etc). There are many resin types on the market, and some debate as to which resin performs best over time. Each manufacturer may publish information relating to the relative qualities of the resins or resin formulations used in their varnishes.

To follow are some examples of acrylic resin in solvent varnishes (where information permits, the solvent type is indicated, although this is not a guarantee of the formulation, as manufacturers may change constituents without notice). Such combinations are often used by conservators, although the exact formulas may change according to the designated use:

- MS2-A resin in Shellsol A
- Paraloid B-72 in Shellsol A
- Paraloid B-72 in ethylacetate
- Regalrez 1094 in Shellsol D 40, with addition of Kraton G 1650, as softening agent (e.g. 2g Kraton to 100g Regalrez)
- Regalrez 1126 in Shellsol A, with addition of Kraton G 1650, as softening agent (e.g. 2g Kraton to 100g Regalrez)
- Paraloid B-67 in white spirit
- Plexisol P 550-40 in white spirit
- Mowilith 35/73 in ethylacetate
- Ketone N resin, in turpentine or white spirit

(N.B. The product codes and identifications may change from those indicated here.)

Correct choice of such varnishes may be dependent on the type of work to be varnished. For example, a dried acrylic painting on canvas will require a solvent-based varnish that is flexible. With mural acrylic paintings, a less flexible varnish may suffice. It is vital to seek sound technical advice prior to undertaking varnishing of finished paintings. It is also important to ensure that the acrylic paint layers are completely dry before over-varnishing with any product containing solvent. If the painting is not wholly dry (cured), the solvent in the varnish may cause bleeding or disturbance in the paint film. In such cases, it is advised to wait for 14 days after the painting has dried, so that any residual moisture is emitted from the paint surface and it is thoroughly dried.

When preparing raw acrylic resin into solvent, it is normal to agitate the mixture at the beginning of the process to encourage the resin to dissolve. If the contents are simply left unstirred in a container, little or even no solving may take place. Placing the raw resin/solvent mixture container into a warm water bath may also encourage the resin to dissolve more readily. For artists, it is always recommended that a proprietary brand of solvent-based acrylic varnish is used, because the types of solvents required to dissolve the resin are usually too noxious to use in normal studio conditions.

The chosen resin is dissolved to form a colourless liquid with some viscosity (according to the solids content). It is usual that such varnishes are further diluted by using mineral (white) spirit, or another appropriate solvent as a thinning agent. Such less-active solvent additions tend to evaporate at a slower rate than the active type, thereby providing a balanced drying time: allowing enough time for the varnish to be brushed out over the painting surface. Low odour thinners (odourless mineral spirit) are not normally used for such varnishes, because they are not active/strong enough to combine with the varnish properly.

A common procedure in the varnishing of an acrylic painting may be to apply a coat of water-based acrylic varnish over the dried painting first to form a sealing or isolation coat. Upon drying, a coat of the appropriate solvent-based acrylic varnish is then applied. This varnish will, technically, be removable, so that it can be replaced should any yellowing/discoloration of the final varnish occur. Such solvent-based varnishes afford protection to paint surfaces from atmospheric pollutants in addition to changing the sheen of the painting surface.

Both water-based and solvent-based acrylic varnishes are now available which contain a UV absorbing material. These do not totally inhibit UV light from acting on the paint film, but may delay the rate of any action. As a consequence, their use is often recommended in the context of outdoor mural paintings, which are exposed to strong sunlight. They may also help to stop the oxidisation of metallic acrylics (those containing copper), thereby preventing tarnishing of the dried paint film.

Some of the acrylic resin examples may be suitable for using as binding agent for pigment, when prepared with solvent: the early acrylic paints followed this idea. Paraloid B-67, solved in white spirit provides a simple acrylic resin solution, which can be pigmented as required. In order to incorporate the pigment into the acrylic resin solution, it is advisable to wet the pigment with white spirit, to form a stiffish paste. This paste is carefully stirred into the viscous acrylic resin solution. If the acrylic resin solution is too thin (too much solvent), the resultant "paint" will be difficult to control. This type of acrylic resin-pigment combination is best applied in flat layers, with the colour being brushed out on to the painting surface. Subsequent coats will tend to pick-up (re-dissolve) the first layer, especially if the surface is agitated. However, this property could be used to produce interesting fused effects. If such acrylic resin-pigment applications are made too thickly, or with multiple layers, cracking may result. However, such systems for painting could be very useful, in so much as the paint is re-soluble with white spirit once dry. This means that dried-up hand-made colours can be re-worked by stirring white spirit back into the container in which they are kept. This re-solubility becomes less easy over time, but is not usually problematic within the first few months of preparation.

Some proprietary brands of acrylic resin in solvent are available, in varying forms: as a viscous syrup; free-flowing varnish consistency; or in aerosol form. Particular care needs to be taken with the latter, as the solvents used to propel the resin during spraying are likely to be very fast to evaporate and as such hazardous to use, should any vapours be inhaled. As always, one should refer to the manufacturers' exact instructions and take any recommended precautions prior to use.

Why Artists Sometimes Mistrust Acrylic Paint

Many claims have been made for acrylic paint: it is permanently flexible, non-yellowing, durable and age-resistant. However, a number of artists are worried that these claims cannot be substantiated, because acrylic paint has not been around for very long. Articles have appeared from time to time in the press, relating to the deterioration of old acrylic paintings. All this adds to the hysteria about acrylic paint: is it really trustworthy and should we use it? After all, we know what happens to oil paint and, despite its defects, oil paint is still preferred by many artists.

There is a danger that acrylic paint is being unfairly damned. It is true that some acrylic paintings have not lasted well, but it appears to be the case that this is more to do with bad practice on the part of the artists, than with the drawbacks of the medium. If we start with the premise that artists intending to produce permanent works use only the best materials, it follows that their work should last the longest. In some of the most celebrated cases where acrylic paint has been seen as the cause of deterioration, it transpires that the artist may have used poor quality materials. In the early days of acrylic painting, often, the cheaper polyvinyl materials were incorrectly assumed to be just the same as true acrylics. Vinyl is a cheaper and simpler material than true acrylic. Vinyl emulsions were, and are still, widely used to make house paints (e.g. matt vinyl emulsion) and as the binder for some childrens' paints. In the confusion over what "acrylic" really means, painting grounds were often made by using a white vinyl emulsion paint as the primer. This type of paint is not designed to be flexible (it is intended for painting walls) and it is quite absorbent. In the DIY trade, it is assumed that people redecorate their houses every 3-5 years: as a consequence, some of their products are designed to last for relatively short periods. It therefore follows that, if you use a non-flexible paint, with minimum binding power, on to a flexible canvas, it is likely that at some point in the future it will begin to deteriorate. Typically, this leads to cracking and/or chalking (dryness) of the paint film. It also has a different flexibility compared with, for example, an overpainting of true acrylic paint: the acrylic paint is more flexible, the white emulsion less so. At some stage, this discrepancy may show itself - when the painting is moved or knocked, parts of the paint layers may become damaged.

Similarly, artists used vinyl-based (PVA - Polyvinyl acetate) paints and mediums for their paintings, sometimes mixing them with true acrylic paints. The PVA-based mediums and paints can embrittle and yellow with age, so it should be no surprise that their use in painting leads to problems. This is still an issue today: lack of resources for students and practising artists, often means that the cheapest materials are used. While this may be unavoidable, it is a great sadness. Not only does this lead to artists making paintings that have a short life-span, it also encourages a bad use of materials and a bad understanding of technique. Part of the blame for this state of affairs lies with education, but it could also be argued that manufacturers should have drawn more attention to the distinctions between true acrylic paint and cheaper PVA/vinyl paints. The main distinctions are as follows:

Acrylic Paint

Paint film remains very flexible, regardless of thickness of application
Long term: acrylic paint remains flexible
Long term: acrylic paint does not yellow or darken
Long term: acrylic paint does not become transparent with age, remains constant
Dilution: water, non-hazardous

PVA/Vinyl Colours

Paint film becomes brittle with age
PVA/vinyl colours have less binding strength than true acrylic paints
Long term: PVA/vinyl colours lose their flexibility
Long term: PVA/vinyl colours can yellow with age

One of the intentions of this text is to persuade artists not to use any PVA-based materials. Often, artists use clear PVA, from a builders' yard, or that intended as a glue for children's artwork, as a transparent sealing coat for canvas. They may also use it to bind dry pigments. This can lead to problems later. Moreover, there are acrylic materials that will do these jobs and which will last.

It can be argued that acrylic paints have a bad name because, in their early use, they were often combined with inferior materials. Artificial ageing tests done by respected conservation specialists, have revealed that high quality acrylic paint is lightfast (non-yellowing), flexible, durable and possesses high binding strength. The words "high quality" are paramount here. Just as in earlier times vinyl-based colours did an injustice to true acrylic paints, so today, there are inferior acrylic paints on the market. They are made with the minimum of fuss, using a true acrylic resin but with the addition of an excess of fillers. Instead of mixing the binder and pigment on a triple mill, costs are cut by simply stirring the ingredients together, so that they form a paint but one which lacks subtlety of consistency and colour. Cheaper pigments are used in minimal quantities. Some of the modern synthetic organic pigments can be extended a long way and still give the impression of colour saturation. However, when such colours are intermixed, instead of giving good mixtures, colour values tend to be muddy. In addition, these economical paints dry quickly on the surface but remain soft at the core for long periods. Ideally, acrylic paint should dry right through to the core at an even rate.

Of course, price is always important to the user: it may be that students will find these cheaper colours ideal for making trial paintings in acrylic. However, the author would suggest that even those new to acrylic should at least try a high quality paint, so that they can judge the differences. Often an expensive, pigment-rich paint can be extended by addition with mediums and/or water, to give much more colour in terms of volume, than is the case with bulk quantity, cheaper acrylic paint.

Priming Information for Acrylic Paint Systems

The choice of priming material for acrylic painting can be crucial. Generally, acrylic primer can be applied to any dirt and grease-free surface. Typically, boards that have been cut at the wood-yard, are prone to having dirty finger marks/residue from cutting. The simplest way to de-grease a surface, such as MDF (medium density fibreboard), hardboard or plywood, is to clean it with a soft rag dampened in alcohol (methylated spirit). The alcohol de-greases the board surface and evaporates rapidly from it. This process should also be applied to the sides of the board and the reverse, so that the object is in effect "clean". Hands can also be cleansed prior to working with acrylic primer, to reduce the possibility of dirt/grease getting back on to the board surface.

Other supports suitable for painting with acrylic primer can include cotton duck canvas, linen, polyester fabric and paper. It may not be necessary to prime paper supports, as acrylic paint will sit comfortably on the paper surface. In general, papers with a surface sizing are desirable, because the acrylic paint does not sink into the fibres of the paper. However, it is dangerous to be too prescriptive about this, because the choice of papers available is so wide and the relative absorbency is also great.

The quality of priming materials for acrylic paint systems varies a great deal from brand to brand. It is impossible to identify one brand as being the best, because that description rather relies on the judgement of the artist. For example, a priming that leaves a very absorbent ground may be exactly what is required by one artist, while another may need a primer with no absorbency. The only way to assess these qualities is to purchase small amounts of different brands and carry out tests. As with all the materials discussed in this text, the same process can be applied: ultimately it is for each individual artist to choose which is the most suitable material for the work in hand.

Generally, acrylic primers fall into two distinct categories:

1. Non-absorbent primer.
2. Absorbent primer, or "gesso".

Both types tend to be manufactured using a blend of titanium white pigment, calcium carbonate (whiting chalk) and acrylic emulsion. The exact absorbency of a primer is dependent upon the ratio of pigment to calcium carbonate. For the most absorbent primer, typically, a greater amount of calcium carbonate is used. The term "gesso"* usually refers to a primer that has more absorbency. However, this is not a standard within the artists' materials trade. It can sometimes simply refer to the fact that it is an acrylic primer. Acrylic primer can also be termed as "universal primer" (signifying that it is suitable for overpainting in any paint media). This confusion of nomenclature is of little help to the artist.

* *Gesso* is the Italian word for gypsum (calcium sulphate). In Italian panel painting, grounds are usually based on a combination of gypsum and animal glue, which tends to be referred to as "traditional gesso". In Northern Europe, artists made a similar ground using animal glue and calcium carbonate (whiting, chalk). Both types of "filler" produced painting grounds that were gently absorbent but suitable only for rigid supports, as they produced paint films that were too brittle for stretched canvas. Modern acrylic-based gesso, should be flexible enough for stretched canvas but can also be used on rigid supports.

As already stated, the choice of the best materials still resides with the artist. By comparing brands, one can find the most suitable material. Ideally, within the painting workshop/dedicated space, a selection of examples of primers should be available, so that sample paint-outs can be made.

The quality of an acrylic primer can be related to the process of manufacture. Economical primers tend to be crudely mixed together, and may not be suitable for further dilution with water. It is essential for the artist to obtain as much technical information as possible about these materials before using them. Manufacturers often produce information sheets about their products, with guidance on their use. Some brands are labelled implicitly with instructions not to be further diluted with water (i.e. they are ready-to-use/pre-diluted). Similarly, check that the primer is suitable for the chosen support. Some primers are labelled as not being suitable for stretched canvas, indicating that they may not be flexible on such supports. The wording on the label may refer to a list of supports for which the primer is suitable, but not mention surfaces for which it should not be used. If in doubt, check with the manufacturer: most have technical support, even if it means talking to more than one person to ascertain the information required. Ideally make a note of the answer given for future reference.

The process of manufacture often governs the pricing of these materials. The longer a material is worked on, the more expensive it may be. For example, some primers are milled thoroughly, more than once, sieved, milled again, then re-sieved. This process removes lumps of material and provides a smooth, fine priming paste. Other primers may be mixed crudely and perhaps not sieved at all. In general, primers that dry to a slightly chalky, matt finish tend towards brittleness. This can be a problem when they are applied to large stretched canvas, where the fabric is under stress. In the worst cases, the weakness of the painting ground (primer) can inform subsequent paint layers (i.e. they crack when stressed). The best quality acrylic primers stay flexible and durable. They may have a higher price but tend to be more cost-effective, because a) they can often be diluted up to 40-50% and b) they do not crack, even when applied dilute.

To achieve the best possible surface (i.e. smooth), there are a number of methods with which the artist can experiment. One aspect to consider is that of brushes. Often, a cheap, decorating brush is used, which gives out a distinct mark. Such brushes also tend to shed hairs badly, contributing to a "bad" surface. Soft hog hair varnish brushes can be used, where the hair is shaped at the tip, so that primer is released slowly from the brush hairs. Sharply cut flat brushes tend to retain brushmarks when applied to a surface. By diluting the priming material with water, to a consistency where it flows off the brush tip, a relatively smooth application of primer can be realised. Typically, a dilution with water of the primer by 25-30% may give a single cream consistency, which flows from the brush tip evenly. As suggested, for each material used, as with each support chosen, some adjustment of proportions may be necessary due to variations between brands etc.

In some instances, primer can be applied and then sanded, either between each coat, or after the final coat. Before doing this, it is advisable to test a number of different primers, to see how successfully they sand down. Generally, the more absorbent acrylic gesso will sand down with greater ease than straight acrylic primer. Some artists use a mixture between acrylic primer and a light acrylic modelling paste, as this helps fill the pores of the canvas fabric, to give an even surface, and can also be gently sanded to provide a smooth finish. Each manufacturer of acrylic material can advise on the best type of light modelling paste to use for this purpose.

In principle, the best acrylic primings stay flexible and provide a cushion for subsequent paint layers. Some brands also produce coloured acrylic primer or gesso. However, it is also possible to admix white acrylic primer or acrylic gesso, with acrylic paint, to achieve a tinted ground.

For some supports, such as linen, a pre-primer may be required. A number of clear, neutral "sizing" agents are available on the market. These can be called "acrylic size", "canvas sealer", "clear acrylic sealant", etc. This acrylic size acts as a sealing agent for absorbent supports, such as linen, where the weave of the fabric is slightly open. When acrylic primer is applied direct to linen, it tends to soak through in places, leaving an uneven surface on the front and reverse. To counter this, the acrylic size is applied, normally in two thinned coats (again refer to directions on product information). This sizing coat penetrates into the weave of the fabric and helps to achieve a homogenous surface when the primer is subsequently applied.

The acrylic size has a matt, virtually neutral quality, which allows subsequent coatings of primer to adhere well. It does not increase tension when applied to stretched canvas, in the same way that animal skin glue sizings tend to.

For best results, canvas is lightly tacked to the stretcher. Two coats of acrylic size are applied, allowing the first coat to dry before proceeding with the second. The first coat can be more dilute than the second. Dilution allows the acrylic size to penetrate successfully into the fabric.

Once dry, the acrylic size can be overpainted with acrylic primer or acrylic gesso as required. If the colour of the canvas needs to be visible, acrylic paint can be applied directly to the acrylic sized surface. However, a third or even fourth coating of acrylic size may be desirable, to ensure that the acrylic paint does not sink into the surface of the painting fabric.

The amount of acrylic size and subsequent coats of acrylic primer can vary, according to the type of fabric used. It is important to make some distinction between priming methods for acrylic paint systems as opposed to oil paint; one method of priming will not suffice for every media. Although acrylic primer can be used for oil painting, it is often necessary to apply more coats of it to avoid strike through.

Encaustic Painting

The term “encaustic” is originally Greek, meaning “to burn in”. It is applied to the use of wax as a binding medium, where no solvent is present. In effect, encaustic painting relies on pigments mixed with a blend of beeswax and natural resin (such as dammar resin). Colour is expressed on to the painting surface by making the pigment-wax-resin mixture molten (fluid) enough to manipulate, with brushes or special tools. The applied paint film quickly cools and sets hard, whence it can be gently buffed with a soft cloth to give a mild polish. Once set and dried, encaustic paints are extremely durable, they do not attract dirt or dust and can be easily cleaned with a soft dusting cloth as required.

N.B. True encaustic painting is applied with heat and never in combination with solvents of any kind (highly flammable). Special oil-pigment sticks for direct painting with colour, are mentioned in the context of oil painting.

Supports for Encaustic Painting

Beeswax is a relatively flexible wax but is not really flexible enough to apply on to stretched canvas. As a consequence, encaustic colour is applied to a rigid panel, prepared with an animal skin glue-chalk mixture (as per panels for use with egg tempera painting). This type of painting ground is porous (absorbent) enough for the encaustic colour to grip on to. Linen, cotton canvas or muslin scrim, stuck to board with animal skin glue could also be used as a support, either with or without a gesso ground.

Acrylic and oil-based primers do not have enough porosity of surface to allow the wax layers to grip on to them.

The support panel must be rigid enough to withstand warping: larger paintings would need to be braced on the reverse to prevent this.

Equipment for Encaustic Painting

Heat is essential for encaustic painting. The paint itself is sold in solid lump form, which needs to become molten before application to the support.

Specialist suppliers of encaustic painting materials can provide the basic equipment, including:

- Thermostat controlled hot plate. Beeswax becomes molten at around 62-66°C. A thermostat controlled hot plate will enable this temperature to be reached easily and kept constant, without over-heating. This is vital, as the temperature must remain constant but never rise above 93°C. Above this temperature, beeswax gives off potentially noxious fumes as do certain pigments (e.g. cadmiums) when strongly heated. It is also the case that some pigments are sensitive to colour change - the ochres and raw siennas are especially prone to this (changing from yellow to red) when strongly heated. In any case, a controlled temperature is advised, so that there is no danger of fire. It is advisable to keep a fire extinguisher within easy reach when working with encaustic, as a precaution.

- Heated spatulas (in a variety of head shapes, for flat applications, smoothing, sculpting, etc). These electronic spatulas provide heat to the tip, so that paint surfaces can be modelled while molten and re-modelled as required once set. A variety of shaped-tips are available.

- Aluminium-steel alloy tins (cake tins, cupcake tins) for holding molten colour. On to the warm hotplate, encaustic colour is deposited into a metal receptacle, such as a cake tin, or baking tin for small cup cakes. Protective oven gloves should be worn when moving the hot tins.

Once softened into a molten, liquid state, the encaustic colour can then be applied to the surface using hog bristle brushes or metal spatulas.

Composition and Use of Encaustic Paints

Encaustic paints rely on a fusion of pigment into molten beeswax and dammar resin. The dried paint film is resistant to moisture, thus providing a very stable final painting. The only caution with finished encaustic paintings is that they be stored away from direct heat sources such as radiators or open fires. They should also be kept away from sources of strong (hot) sunlight during the summer months.

Beeswax is available in both lump and pellet form. In its raw state, natural beeswax has some flexibility, but this is somewhat reduced in refined products. With the artists' materials market, most beeswax can be considered as being refined to some extent. The refined product is sold in a yellow or bleached form. The latter has a white colour and is seemingly more useful when combining with pigment. In practice, the colour of the wax is of little importance, as the bleached wax will revert to the same colour shade as the yellow wax over time. Raw natural beeswax, procured from the bee-keeper, will be more plastic (flexible) and higher in resin content than the refined forms. The raw product is also less likely to be adulterated: some refined beeswax may have inclusions of synthetic waxes. However, raw natural beeswax may have a stronger colour (typically yellow-brown), which may have some drawbacks when being used with pale colours and whites.

In an enamel pan, the beeswax is melted on a hotplate, together with an inclusion of perhaps 30% dry dammar resin. Choose the palest pieces of dammar available and pick through it before use, to remove any plant impurities and other foreign matter. If too much is added, the encaustic paint will be too sticky when molten. Experimentation is called for in this respect. The inclusion of dammar gives the resultant encaustic paint more gloss and better hardness upon drying. During the melting process, the contents of the enamel pan are stirred to ensure fusion between the two ingredients. When adding pigment to colour the wax-resin, it is advisable to take the pan off the heat, stir in the dry pigment (while still hot) so that all the dry powder is incorporated into the wax-resin, then place back onto the heat source and stir until the pigment is freely distributed in the wax-resin. The longer this stirring can continue, the better the mixing of the ingredients will be. Some pigments with larger particle size, such as the natural earths, will take longer to mix in than those with smaller particle grain size.

When the ingredients are thoroughly combined, the mixture can be poured into small empty bread tins or cupcake tins and left to cool and harden. When each colour is required, it is simply re-melted in its tin and used. It is possible to mix colours by melting the required colours, then combining while still hot, into a new receptacle. It is much easier to mix colours this way, than to try and mix colours on the painting surface. Once the chosen palette has been decided upon, it may be appropriate to make up some half-tints with white, or perhaps neutral tints towards black, by the addition of a transparent black such as lamp black.

Wax Types

Beeswax is the most useful wax for encaustic, being slightly flexible and easy to melt and re-melt. The other waxes can be experimented with, but may cause more problems than they solve - with the possible exception of carnauba wax.

Carnuaba Wax

Carnuaba wax melts at 83-86°C. A natural plant wax, from South America, it can be incorporated into encaustic colours to impart toughness and durability to the paint sheen. An addition of perhaps 5-10% of the wax content in the encaustic block will produce a wax paint that melts at a higher temperature but will bring a certain hardness to the cooled paint film. The importance of using a thermostat controlled hotplate becomes crucial when adding this higher melt-point wax to beeswax. Carnauba wax is sold in a grey (natural) form, or a pale white-yellow colour (refined).

Paraffin Wax

Paraffin wax melts at around 50-60°C. It is a by-product of the petro-chemical industry. Paraffin wax is too brittle to use in encaustic paints and, with a low melt point, would make the cooled paint surface very susceptible to change in warm environments.

Microcrystalline Wax

Microcrystalline wax is related to paraffin wax, but may have a higher melt point, according to the grade selected (e.g. 73-77° C). It may be more flexible than paraffin wax, however, some cheaper grades may be even more inflexible!

A special grade of microcrystalline wax, called “Cosmoloid” wax has a higher melt point (around 80-100°C), which may be useful, but only when used in relatively thin layers and with pigments that don’t give off noxious fumes at high temperature.

Other waxes are available (none of which are commonly used in encaustic technique):

Candelilla wax (melt point, 67-71°C). A brown plant wax. Similar hardness to carnauba wax.
Insect wax (melt point, 79-83°C). Yellow-white in colour, harder than beeswax.
Japan wax (melt point, 50-52°C). Very soft, sticky insect wax, which remains soft upon cooling. Pale yellow colour.
Montan wax – ozokerite (melt point, 76-130°C). Brown-black wax from bitumen.
Ceresin wax (melt point, 61-80°C). Derived from bitumen, ceresin wax is a refined form of brown-black ozokerite mineral wax, with a pale, yellow colour. More flexible than paraffin or microcrystalline waxes.

Stearin wax (melt point, 69-71°C). Animal fat wax, pale white-yellow colour, soft. Most often used as an additive (adulterant) in candle making or cosmetics.

Spermaceti wax (melt point, 41-44°C). Brittle, white wax, from the sperm whale.

Suggested Palette for Encaustic Painting

It is vital that the pigments used in the composition of encaustic paint are not heated to high temperatures. As previously indicated, beeswax must never be heated beyond 93°C, to avoid wax fumes.

It is also crucial to keep the temperature constant and always below 93°C, because some pigments can a) give off toxic fumes when overheated (e.g. cadmiums) and b), change colour when strongly heated (e.g. natural earths). If kept at a stable, gentle temperature (around 66°C), the following list of pigments can be used:

Cadmium lemon
Cadmium yellow light
Cadmium yellow medium
Cadmium yellow deep
Cadmium orange
Cadmium red light
Cadmium red medium
Cadmium red deep
Cadmium maroon
Cadmium green
Cobalt yellow
Cobalt violet light
Cobalt violet deep
Cobalt blue
Cobalt turquoise
Cerulean blue
Cobalt green
Synthetic iron oxides: yellow-orange-red-violet, brown, black
Nickel titanium yellow

Paliogen maroon

Quinacridone red, pink, violet

Manganese violet

Ultramarine violet

Ultramarine blue

Prussian blue

Phthalocyanine blue

Phthalocyanine green

Ultramarine green

Viridian

Chrome oxide green

Green earth

Natural earths: raw sienna, burnt sienna, raw umber, burnt umber

Ivory black

Lamp black

Titanium white

Zinc white

N.B. Avoid all lead-based pigments in encaustic technique.

Painting Techniques

In the soft, molten state, encaustic can be applied to the painting surface in a number of ways. From the hot tin in which the encaustic has been melted, the contents can be poured out on to the surface, or applied with hog bristle brushes, or painting knives, spatulas, etc. Some improvisation is called for in terms of application. Speed is of the essence, as the encaustic colour soon cools and hardens. If the encaustic cools before the surface of the paint has been manipulated, it can be re-worked with a flat head heated spatula. It is also possible to move the painting close to a heat source (e.g. a hot radiator), to soften the paint surface for re-working. If paint needs to be taken off, it can simply be melted with a hot spatula and scraped off.

It is advisable to work in relatively thin layers, slowly building up translucent layers of wax. The strength of the colour used can be controlled by admixture with more beeswax and resin. This is best done by preparing a block of colourless encaustic paint, containing only melted beeswax and dammar resin. The resultant block can be made molten with heat and poured into tins containing strong colour, as a kind of diluent or extender. If too much wax-resin is contained in a paint mixture, the resultant paint sheen may take on a frosted/obscured appearance, where the thickness of the wax-resin in comparison to the pigment content subdues colour resonance. Some experimentation is called for in these circumstances. Of course, once cool, any difficult areas can be quickly overpainted, or re-melted and removed as required.

Never add solvents into encaustic paints: the low flash points of solvents such as white spirit and turpentine would make fire a distinct possibility. Encaustic is best used alone, rather than in combination with other media. However, an 18th century formula for working with wax involved the covering of a wooden panel with a thick (3cm plus) layer of beeswax, poured on to the surface and worked over with heat to gain a flat, level surface. On to the cooled wax surface, gouache paint is applied (without dilution with water), to create an image. Once dry, the finished gouache on wax painting is taken close to a heat source and exposed to heat for a few moments. This can be done by hovering over the paint surface (laid flat) with a heat gun. The heat gently melts the wax, and the gouache paint is quickly absorbed into it. Once cool again, it is found that the paint layers have become embedded in the wax, so providing a stable and durable paint surface. If the wax is melted too quickly, the painted image may separate or crack, although in abstract painting terms, this may be of some benefit. The cooled wax surface can be gently buffed to give a soft polish. Alternatively, subsequent layering of encaustic can be applied over this "underpainting".

Glazing with Encaustic

Wax has a frosting effect on paint films, when it is applied in any thickness. By contrast, when encaustic is applied in relatively thin layers, translucency within the paint film is preserved. As a consequence, pigments that are normally transparent in other binding media, will retain their transparent properties when applied in relatively thin layers of encaustic, but will exhibit an opaque, solid presence when applied thickly.

Working in Layers

When applying multiple layers of encaustic, it is important to heat the whole painting gently after completion, to ensure that all the layers bond together. This gentle heating is best done with a heat gun, held perhaps 40-50cm from the painting surface. The heat gently warms the paint surface until it becomes soft and just molten. This process (known as “fusing”) softens the various layers so that they all fuse together, ensuring correct bonding between layers. The painting is laid flat during this process, so that the wax layers do not start to run. If the painting is not fused in this way, either upon completion, or while working, it is possible that one layer may shear off from another.

As with most paint systems, encaustic is best applied in multiple thin layers rather than thick wodges. However, the durability of encaustic when applied to a rigid support does allow for some degree of impasto and indeed, applied paint layers can be worked into with heated spatulas in order to part-sculpt the paint surface.

Presentation of Finished Encaustic Paintings

Encaustic paintings do not need to be varnished: the surface, once buffed with a soft cloth, will resist collection of dirt and dust. The surface is also resistant to water, so can be wiped with a damp cloth to clean. For exhibition, encaustic paintings can be shown without glazing, indeed, putting encaustic paintings under glass would somewhat detract from the paint's inherent qualities.

Safe Clean-Up of Encaustic Paint

As already indicated, some precautions are necessary with encaustic technique. Aside from the use of a thermostat controlled hot plate, a fire extinguisher should be kept close at hand. In addition, heat resistant gloves should be worn when handling hot paint tins, etc. Used brushes can be cleaned by rinsing in a tin of molten wax. This should free the encaustic paint from the brush hairs. However, in practice it may be better to nominate each colour a specific brush, so that cleaning is unnecessary. In this case, the brush need only be re-dispersed in the same colour in the molten state. It is also possible to clean brushes by rinsing in a molten solution of (cheaper) synthetic wax, such as paraffin wax. However, the synthetic waxes are never used for encaustic painting itself, because they generally have a lower melt point and are more prone to cracking/splitting upon cooling.

Lime-Fresco Painting

Fresco (literally "fresh") refers to the practice of painting using pigments dispersed into water, on to a base of wet lime plaster. True fresco (*buon fresco*) is applied in this way, relying on the setting properties of lime to capture pigment particles worked on to the lime plaster (*intonaco*) surface.

Lime is calcium oxide, prepared by burning calcium carbonate (e.g. limestone, marble, etc) in a brick kiln. Not all varieties of lime are suitable for use in fresco painting. Ideally, the lime is free of magnesium and not tinted by iron oxides. Not all sources of limestone concur with these requirements. Additionally, commercial suppliers of lime deal almost exclusively with the building trade and building restoration trade, where the need for very finely sieved, high white colour lime may not be as important as it is for fresco painting.

When lime is introduced to water, it provokes a strong reaction, being an aggressively caustic alkali. On immersion into water, heat is generated and the material is formed into a new substance, calcium hydroxide, also referred to as "slaked lime". The best qualities of slaked lime are derived from lime that has been left to "rot" in tanks of water. This process of ageing the soaked lime, provides the best possible adhesion to the support and coherent setting of the lime paste. During this process, the wet slaked lime settles out in the tank: the finest particles stay at the top of the wet lime slurry, while the larger, coarse particles descend towards the bottom. The tank must be dug into the ground, ideally below the surface so that frost cannot develop, as this would injure the setting properties of the lime. The tank must also be covered at night, to prevent frost from developing.

In the traditional use for lime - the white-washing of houses and the preparation of lime plaster - the slaked lime need not be of a uniform consistency. However, for use as an artists' paint system, the smoother the lime paste, the better, in terms of achieving fine results.

When applied on to the correct substrate, the slaked lime (calcium hydroxide) changes back to calcium carbonate on exposure to carbon dioxide in the air. As the applied slaked lime dries with the evaporation of the water content, it gradually reverts back to calcium carbonate, in reality, a chemical change occurs to the original material (e.g. limestone, marble, etc). Upon hardening, the dried lime layer becomes as hard as rock; the individual particles of lime being strongly bonded to each other. It follows that when pigments are mixed with distilled water to form a liquid paste, then applied to the fresh lime layer, the pigment particles become trapped within the structure of the re-forming calcium carbonate, thereby resulting in a hard-set and durable paint film.

Health and Safety Precautions

Lime is a caustic, alkaline material, which can burn the skin and is especially dangerous when in contact with the eyes. As a consequence, it is advised that at all times, preventative measures are taken.

Wear protective eye goggles, gloves, barrier cream (applied to hands, forearms, face and neck - any part of the skin which could be exposed) and a dust mask when working with dry pigments. Never eat or drink in the studio when working with lime. The clothes worn while working with lime must be removed on leaving the studio, as residual dried lime dust can easily be brushed off on to skin, etc. It is imperative to wear eye goggles, because the wet lime paste is prone to a certain amount of splashing, when pouring, painting, etc.

Once absolutely dry, fresco paintings become relatively inert.

Supports for Lime: Preparing Walls and Other Substrates for Application of Lime

The wall structure is prepared so that it will take subsequent coats of mortar. Preparation will vary according to the structure in question. For example, an old, aged plaster coating over brick may be simply hacked all over to provide a grip coat. If the wall structure is clean, aged brick, the bricks themselves will possess enough porosity to allow the first scratch coat to form a bonding. In the case of walls they must be free from any minerals, especially salt residues. Preferably, the wall should be specially constructed, including an air cavity between the wall to be painted on and the structural wall of the building. It is advised that this air cavity be designed to allow air to circulate (i.e. it is not a simple void of trapped air, there are holes that allow the air space to "breathe"). It is also advisable to ensure that any wall structure is free from damp and does not contain any residual moisture prior to painting.

Once the wall is prepared, before application of the scratch coat, the wall is soaked with cold water, the purpose being to penetrate the porous wall, so that the scratch coat partially absorbs into the wall itself to form a coherent bonding. The wall is repeatedly soaked, as evenly as possible, until it will not absorb any more water. At this point, the scratch coat is applied.

For portable panels, the procedure is simpler, as described later in this section.

The Mortar Layers

The following aggregates are suggested for use in lime mortars:

Marble dust, white offered in a variety of grind sizes, μ, for example:

Finest	32μ or less (marble flour)
Fine	32μ

Middle 90μ
Coarse 200μ
Extra coarse 150-300μ

Marble chips, sold in a variety of colours and grind sizes (use white for mortar layers):

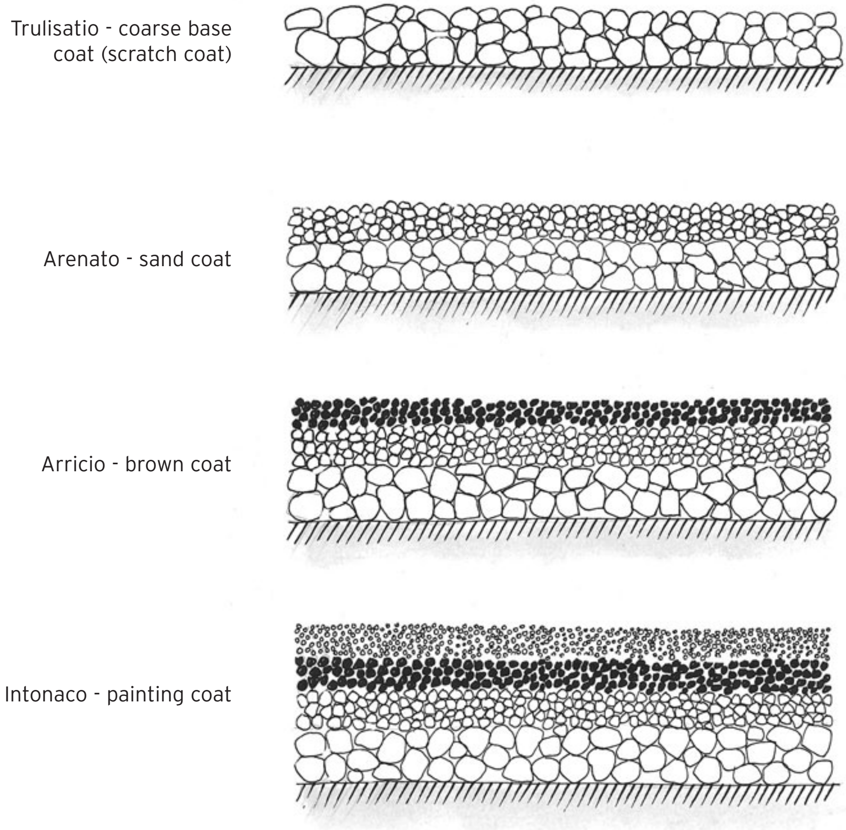
Sand texture	0.7-1.2mm
Grit texture	1.8-2.5mm
Gravel	2.5-4.0mm

(In practice, a mix between marble chips and dust may be preferable, but experimentation is called for at all stages with lime-fresco painting.)

Quartz chips (white river sand, free of mica), in grind sizes from 0.15mm to 0.5mm.

These aggregates are presented in different "grind", or "grain" sizes (particle size format). In true fresco, the wall is prepared by combining coarse aggregates into lime putty in the first coat, followed by subsequent coats that may contain a higher proportion of lime, and increasingly less-coarse inclusions of aggregates. There is some evidence that in the first coats (*trulisatio*, *arenato*) a mix of coarse and medium grind aggregates is advantageous. While this provides a relatively gritty and coarse structure, the in-fill is completed with smaller sized particles. These help to keep the mortar structure slightly damp, when residual water from the intonaco layer percolates down into the mortar, thereby giving a longer working period for application of colour to the intonaco layer.

According to traditional Italian techniques, the support layers of mortar are applied to the prepared wall surface, in the following sequence:



Mortar Layers for Fresco Painting

Trulisatio - coarse base coat, or scratch coat, containing larger-sized aggregates (white river sand/quartz chips, or coarse marble dust). For example, take marble dust chips, sized 2.5-4.0mm and combine 3 parts marble dust chips with 1 part lime putty. The use of aggregates helps to form a solid and stable working surface. By including these coarse materials, the mortar coats tend to dry with minimum shrinkage. The large grain marble dust chips/quartz chips will stand out proud from the dried mortar to some extent: this gives a kind of grip coat for the next layer of mortar. By gradually adding finer grain size aggregate to larger inclusions of lime putty, the "wall" structure of the mortar is brought to a smooth, relatively even finish.

Arenato - consolidation coat, or sand coat, applied over the trulisatio layer: a mixture of 1 part lime to 2 parts marble dust chips, 0.7-1.2mm grind size.

Arriccio - underpainting coat, or brown coat, applied over the arenato coat. It is composed of fine quartz sand or marble dust with an equal quantity of lime putty.

Intonaco - the painting coat, usually made with fine lime putty. While still damp, pigments mixed with distilled water are applied to the intonaco layer. The pigments are driven into the surface of the layer upon evaporation of the water content, becoming intrinsically bonded into the structure. While the intonaco layer is still damp (but not saturated with wetness), colour can be safely applied and a bonding can be assumed. However, once the intonaco layer is dry, applied colour will not form a reaction with the lime and little or no bonding will occur. As a consequence, large-scale work is usually undertaken with some planning, the intonaco layer only being applied to an area that can be worked on comfortably before drying out.

The preparation of the previous mortar layers can be crucial to the way the intonaco layer operates. The mortar layers are applied loosely (i.e. without undue pressure being applied during trowelling of the mortar) and the material is not especially compacted during this process. This leaves the underlayers of lime-mortar relatively porous, so that when the intonaco layer is applied, some dampness percolates into the mortar layer and remains within it for a protracted period, thus allowing a longer working time on to the freshly applied intonaco layer. However, if the mortar layer is too porous, too much water will be sucked out of the intonaco layer. By tradition, the coarse layers of mortar are applied by throwing the mixed mortar at the wall surface, from a metal trowel. Once they have contacted with the wall structure, the trowel is used if necessary to gently form a level coating of mortar. In the first stages, the material is not compacted down on to the support structure: it is gently levelled, but not aggressively pushed against the support. This method of application allows the mortar to retain a little porosity. If the mortar were to be strongly compacted, too smooth a layer would result. This layer would also be less liable to retain moisture, when the final intonaco layer is applied.

The mortar is then left to dry for 20-30 minutes before the next coat is applied. Allow this amount of time so that the mortar is still slightly wet but not sopping. A good method for testing at this stage is to press the thumb against the mortar layer gently. One should be able to leave a firmish thumb impression in it: if the mortar gives way (goes to a sludge), then more drying time is required. If the mortar coats are laid down in this manner (i.e. without complete drying between each coat), then theoretically the different coats are better bonded together. However, some experimentation may be required and it should be borne in mind that different atmospheric conditions may cause the mortar layers to dry out at variable rates.

However, with the final intonaco layer, the trowelling is followed by compaction of the surface, to gain a hard, smooth finish. To avoid "popping" of the surface (the rising of air bubbles and water through the final coat), it is worked over with a special lime or chalk brush, which helps to free any residual pockets of air or water, so creating an even and unpock-marked surface.

Portable Panels

The preparation of wall structures for lime-fresco painting is a somewhat protracted and technical matter, which may require consultation prior to working with an appropriate authority. By contrast, artists can prepare a form of portable panel, which allows smaller scale work to be undertaken in lime-fresco.

There are two basic types of portable panel that can be used:

1. Support layers on to wood panel.
2. Support layers on to plaster panel.

Wood Panel

MDF (medium density fibreboard), of at least 15mm thickness can be used to make small panels, up to 50cm square (larger size formats will tend to warp and would require significant bracing). The preparation of the panel gives a synthesis of a wall-mortar, but is arrived at by the inclusion of casein (milk glue), as a strong bonding agent. The casein allows the coarse particles of quartz/marble to grip on to the panel, and the top layers to be painted in lime only. Casein is a very strong protein glue, which will enclose and grip larger particle aggregates in the mortar layers. Because it is so strong, the intonaco coat of lime will not pull away from the mortar layers. Also, casein is a porous glue, which allows moisture from the intonaco layer to percolate down into the mortar layers, as with traditional fresco. However, it is important to ensure that each layer of mortar is slightly weaker than the last (in terms of the strength of the casein glue), to prevent the strong nature of the glue from shearing away from previous coats. This is simply done, by preparing the mortar coats with increasingly dilute additions of casein binder.

For the first coat – the grip or scratch coat - take 3 parts coarse marble chips ("gravel", 2.5-4.0mm) to 1 part of lime putty. Mix these thoroughly. To this paste, add about 30-40% casein binder. The casein is prepared into a stock solution as follows:

Lactic casein	2 parts
Cold water	8 parts

Add the water to the casein. Then add 1 part (i.e. 1 level tablespoon) of powdered ammonium-carbonate, which acts as an emulsifying agent, allowing the casein and water to form a thick paste. Leave to stand for 15-30 minutes, stir to free any lumps. To this paste, slowly add a further 8 parts of cold water, stir again until free from lumps. Sieve if necessary. It may be advisable to leave this to stand for an hour or so, to allow the ammonium carbonate to settle. It eventually effervesces out of the mixture, so plays little or no part in the formation of the dried paint film. Once sieved and in a free flowing, but thick solution, the casein is ready for use. At this dilution it is added to the lime-aggregate paste, as already suggested.

Before applying to the panel, make sure that the panel is dirt and grease-free. If necessary, de-grease the surface of the panel with alcohol. Leave to dry for at least 3-4 hours after preparation with alcohol. The first mortar coat is then applied, by brush to the panel. A large round hog fresco brush (*muccino*) is used. This ensures that the first coat contacts with the panel and that no air pockets or gaps are left. While the mortar-casein mix is still wet, work the brush over the surface to give an even distribution of the aggregates. Leave this first coat to dry completely, perhaps for 2-3 hours.

The second coat is applied in the same manner, but this time a mix of 2 parts marble chips ("grit" texture 1.8-2.5mm) is mixed with 1 part of lime. To this paste, 30-40% casein binder is added. However, with this coat, the casein binder is diluted with another 8 parts water, to make its glue strength relatively weaker than the first scratch coat.

Once dry, the third coat is applied, this time using an equal mixture of marble chips ("sand" texture 0.7-1.2mm) to lime putty. In this third coat, again the casein binder is added about 30-40%, but again it has to be diluted with a further 8 parts of cold water. During application, it may be useful to run a smooth spatula over the surface to create an even texture, or this can be done by careful brushing. In practice, the author has also found it possible to wait for this third coat to dry, then abrade with glass paper to achieve a smoother surface.

Once this third coat is dry, the intonaco layer can be applied (1 part lime putty to 1 part fine marble flour/marble dust). It is useful to do this using a trowel and patting the surface of the lime, so that it is compacted against the mortar coats. As with normal fresco technique, the intonaco layer can also be smoothed by brushing flat, this will eradicate any air or water trapped in the surface. It is best to leave the applied intonaco a few minutes before doing this, to allow the surface to settle out. Into the damp intonaco layer, pigment-water paste can be applied, and the paint film will dry out as expected, with the pigment particles bonded into the lime intonaco.

Plaster Panel

Plaster of Paris is a form of gypsum, where the material has been calcined so that a large portion of its inherent water of crystallisation has been eradicated. Upon mixing with cold water, such plaster is driven to set extremely quickly. During setting, the plaster hardens before it loses all the water that has been mixed with it, so allowing a firm set, without undue shrinkage. As a consequence, such plaster is used for casting in sculptural techniques, but it can also be used to make a thick, flat panel, suitable for applying mortar layers on to.

Choose a fine grade plaster, which is quick setting. This is usually a hard white, finely and evenly divided powder. Use cold water, slowly stirring it into the dry plaster, to form a smooth paste. This procedure must be undertaken quickly. In practice, the best way to incorporate the water into the plaster is to mix by hand. First, apply a barrier cream to the hands and forearms, then wear some protective gloves, so that the plaster does not come into contact with skin. Slowly combine the water with the plaster and stir, using the hand like a paddle to form a smooth, air bubble-free paste. This paste is then quickly poured out into the panel mould.

It is suggested that the plaster panel be small in size, no bigger than 50cm square. Cut a strong piece of wood to this size, to act as a kind of backing. This will ensure that the back of the panel is completely smooth. Cut strips of strong cardboard, or thin wood to act as a mould, and go around the edge of the wooden panel with these strips, so that the plaster can be poured over the wood panel and kept in this reservoir by the retaining walls of cardboard/wood strips. Hold the strips in place by going around the outside with strong adhesive packing tape. Into this reservoir, place a thin sheet of polythene to act as a barrier between the plaster and the wood panel and edge strips. Once the mould is secured, pour in the freshly mixed plaster, quickly spreading it across the inside of the mould using the hand, or a flat hog brush. The plaster should come up to a thickness of between 6-8cm. As long as the plaster is mixed to a fine slurry and free from air bubbles, it should form a strong base panel. Such panels tend to take a long time to cure (dry out), as water is pushed out to the top of the mixture as the material starts to harden. This process can be quickened, by drawing off excess water as it collects on the surface, or even by carefully soaking the excess water on to an absorbent paper and lifting out.

Once completely dried, the mould is removed and the panel is ready for use. Before applying the mortar coats (as described for normal walls), the surface of the plaster panel can be abraded using very coarse glass paper, or even by grating using a metal file, or any implement that will make many shallow incisions into the plaster. It is vital to do this, to ensure that the mortar coats have something to grip to and bond with.

It is also possible to include some aggregate into the wet plaster, although this does make the formation of a consistent panel rather more difficult. Another possibility is to lay a coarsely woven piece of hessian, jute or linen into the setting plaster, or to lay down one coat of plaster, overlay the fabric, then while everything is still fresh, apply another coat of plaster on top. The inclusion of this kind of fabric tends to give a stronger panel. Alternatively, fine horse hair can be mixed with the plaster to achieve a similar toughening of the plaster base.

Pigments for Lime-Fresco

The best pigments for use in lime-fresco are those that are chemically inert, or at least not sensitive to alkalis. This precludes the use of typically alkali-destroyed pigments such as prussian blue. The air in the environment may also cause pigments that are affected by acidity to become altered. Care should be taken when working on outdoor fresco paintings, to choose only those pigments that are stable in all conditions.

Basic Palette of Fresco Pigments

The following list of pigments provides a starting point, as a basic palette. Further information on use of pigments in lime-fresco is touched on in the pigment section. In truth, it is impossible to guarantee the safe use of any pigment in lime-fresco technique, due to the possibility that during manufacture, even the most inert pigments may have impurities or additives which can cause reactions when in contact with lime. It is advisable to confer with manufacturers/suppliers of fresco materials to determine their appropriate use in this technique.

On to a test panel (e.g. a panel prepared with plaster as previously described), make up small batches of pigment-distilled water pastes and apply these on to a layer of fresh intonaco. Leave this sample panel to dry for at least six months. During this period, any reaction should show: for example, effervescence on the surface; discoloration, or fading (leave panel exposed to south facing sunlight).

By tradition, each pigment is carefully mixed with cold distilled water into a paste, then applied to the wet (or rather damp) lime plaster surface. It is also possible to admix lime with the water paste to improve adhesion, although this will cause the dried colour to take on a pastel shade, rather than full tint strength. Some pigments are sold as prepared water pastes, which can be used directly on to wet or damp lime plaster, although some dilution with water prior to use may be advised, so that the applied colour is not streaky. These water-pigment pastes are especially useful in connection with the synthetic organic pigments, which have a very fine particle size and can be difficult to disperse into water.

This list is intended as a starting point and many other pigments may be used, as confirmed by the relevant supplier, etc.:

White	Bianco san giovanni (smooth white lime, partially carbonised) Slaked lime (always as a wet paste) Zinc white Titanium white
Yellow	Synthetic iron oxide yellows (mars yellow) Natural yellow earths: ochre, sienna, etc. Nickel titanium yellow Permanent yellow (PY 154) Cadmium yellow (for interior use only)
Red	Synthetic iron oxide reds (mars red) Natural red earths: burnt sienna, etc. Irgazine red (PR 254) Paliogen maroon (PR179)
Blue	Cobalt blue Cerulean blue Azurite (when applied freshly - if left to stand in water, will turn greenish) Phthalocyanine blue (PB 15) Indanthrene blue (PB 60)
Green	Viridian Cobalt green Green earth Chrome oxide green Phthalocyanine green (PG 7)

Black	Synthetic iron oxide black (mars black)
	Spinel black
	Manganese black

In the case of the synthetic organic pigments, the Colour Index name is given to aid identification.

Whites in Lime-Fresco

The intonaco layer and the mortar layers are normally prepared using a good quality aged lime putty. For example, putties that have been left to steep in water (slaked) for at least three years, possess the best setting characteristics. New lime putty (less than six months) will not set as quickly or as thoroughly. In fact, such lime putties tend to form cracks or surface deposits upon drying. While it may be impractical for individual artists to prepare their own lime, in recent years there has been a revival of interest in fresco painting, and a number of specialist suppliers now offer aged lime putties. In practical terms, the longer the lime has been left to slake, the better its setting qualities become.

The white colour of lime can be utilised as a colour during painting. Pigment-distilled water paste can be co-mixed with lime putty to achieve pastel tints. However, such applications tend to have a slightly dull appearance, compared with very thin applications of pigment applied over the damp intonaco layer. This is because, when pigment is mixed directly into the lime putty, the larger particles of lime tend to take a more prominent position in the mixture. So much so, that some pigments with a small particle size will virtually disappear. This is especially the case with the synthetic organic pigments, which are composed of extremely fine particles. As a consequence, fresco painters tend to shy away from the use of pigment mixed with lime putty. Indeed, this technique is more common in the decoration of buildings, where a tint of colour (e.g. an earth pigment) is produced by admixture with lime putty.

A more successful way of using pigment with lime white, is to mix the pigment-water paste into lime-water (sometimes referred to as “milk of lime”). Lime-water can be said to be the residual water that forms on the surface of the lime putty. In the formation tank, this water tends to clarify readily once the lime has been left to age for a few months. In practice, unless one has access to a tank of aged lime, this lime-water is best obtained from aged lime putty, which is sold in large quantities (e.g. 25 litre, or 50 litre bucket). On opening these buckets of aged lime, it will be observed that clear water settles out at the top of the mixture. This can be carefully drawn off and used as lime-water. Because lime dissolves (over time) into cold water, even though the lime-water looks clear, upon evaporation of the water content it will reveal a slight white residue. However, this residue is minimal and does not unduly affect colours it is mixed with, especially large particle pigments (e.g. earth pigments, synthetic iron oxides). If a paste of pigment-water is introduced to an equal volume of lime-water, it can be used to effect thin glazes of colour over the damp intonaco. The added lime in the lime-water creates extra bonding of the pigment into the carbonised lime putty structure upon drying, so forming a very hard-wearing bond. In practice, the pigment particles become as one with the newly formed calcium carbonate structure of the dried intonaco layer. Thus, the resultant painting is age and weather-resistant to a great degree.

Bianco san giovanni is a form of lime that has been exposed to air and is therefore closer to carbonisation than normal lime putty. By tradition, the finest grain-size basic lime putty is taken from the top of the lime pit and formed into small cakes, then left to dry for 3-4 months in a dust-free environment. When used as pigment, mixed again with distilled water, then applied to the damp intonaco layer, it dries to becomes extremely hard and fast-setting. The best quality bianco san giovanni will also have been finely sieved, so that only the finest powder is used.

Blanc fix is sometimes used in fresco as a white. Indeed, when used as a water-pigment paste, applied on to the intonaco layer, blanc fix shows as a brilliant white. This is not the case when blanc fix is used with other binding agents, where the colour and thickness of film of the binder tends to mask the whiteness of the pigment.

Titanium and zinc whites can be used in fresco safely, although these colours (being relatively late in terms of their introduction to the painter's palette) bear no relation to the whites used in traditional fresco painting.

It should be obvious that lead white can never be used in true fresco techniques, as all lead-containing pigments are inevitably changed upon exposure to air. This is especially true in the case of fresco, where the pigment particles are merely trapped in the dried calcium carbonate structure: air can still act on these pigment particles and so it follows that atmospheric pollutants will quickly make their presence known. For this reason, fresco painters are best advised to work with inert pigments, especially if the completed work is situated outdoors. There is some evidence that sulphide containing pigments, such as the cadmiums, can be safely used for indoor fresco painting but tests should be made prior to execution.

Bone ash is sometimes used as pigment in fresco painting. It has a soft grey colour in the dry state. It is also used in fresco to thicken the consistency of water-pigment pastes: because it has very little tinting power, it can be used (add 10-20% bone ash) to make a fat paste with pigments that have small sized particles (e.g. synthetic organic pigments). This will make such pigments easier to spread out over the surface, without changing the colour value too much.

Application of Colours

Before painting, it is common to execute a cartoon underpainting on to the wet/damp intonaco layer. By tradition, this is done with a natural red earth pigment, sinopia. This cartoon drawing or underpainting can be used as a guide for later painting. Once the cartoon is dry, a new intonaco coat (which remains slightly transparent, allowing the basic cartoon design to be followed) is painted over the top, on to which the actual painting is made. This final intonaco layer over the cartoon may be derived from lime only, compacted on to the surface by trowel application and further smoothed using a brush as previously described.

The pigment-distilled water pastes are spread over the surface of the (top coat) wet/damp intonaco layer, usually with brushes. The surface of the intonaco is gently absorbent and allows some of the colour to percolate down into the mortar structure. Correct preparation of the mortar and intonaco is therefore crucial. Again, it is advisable to make some test panels, keeping a note of the exact recipes used for each mortar layer, prior to undertaking major paintings. As already suggested, the use of lime-water with the pigment and distilled water pastes, will help adhesion and film formation. Admixture with lime-water may also assist larger particle size pigments (such as the historic, mineral pigments) to be spread out over the surface, allowing the particles to be dispersed, rather than clustered together. With pigments such as malachite and azurite, this technique helps to show the crystalline nature of the colour, as light catches on the exposed particles.

Because the intonaco layer is still damp during the paint process it is susceptible to disturbance. For this reason, the brushing on of pigment-distilled water paints is done with some care. It helps if the intonaco layer has been applied firmly, where the material has been compacted with a trowel and subsequent brushing, as previously described. Again, trial and error through experimentation is called for. Another tip with fresco, is to remember to be patient. The dried surface is only truly dry when all the water has evaporated. This can take many days. During this period, the surface of the painting is not always fixed (i.e. it may look dry, but the image can be dislodged with gentle rubbing). The complete carbonisation of the intonaco layer is required for fixing of the image. If the surface remains in a smudgeable/moveable state after complete drying, this may indicate that the mortar layers are simply too absorbent, or too thick.

Fresco Secco

Fresco secco (dry technique) is applied to the same substrate, but after the intonaco layer has thoroughly dried. With fresco secco, pigments are then mixed with a protein binder such as casein (milk glue) and applied to the dried intonaco layer. The resultant finish bears a close resemblance to true fresco but is not as weather and age resistant. Fresco secco allows certain fragile pigments to be applied, which would be destroyed by the caustic, alkaline nature of wet lime. For example, plant based pigments, such as stil de grain or madder, are quickly affected by lime. When used 'a secco', such pigments do not react with the dried intonaco layer. Also delicate colours, which would show as a tint only when used in true fresco technique, may benefit from fresco secco application.

Casein is perhaps the best binder for this technique and it is prepared as follows:

Casein	2 parts
Cold water	16 parts
Ammonium carbonate	1 part

The casein powder and water are combined, the ammonium carbonate added to aid emulsification. After stirring and leaving to stand for 30 minutes or so, a solution is formed. A further 16 parts water is added to the basic solution, to form a single cream consistency. It is advised that pigment is mixed into this solution and then diluted further with water, to achieve a thin paint film - the thinner the better. If the casein is over strong, it may pull at the lime substrate and cause weaknesses in the mortar/intonaco layer.

Other types of protein glue have been found on old fresco secco paintings. For example, egg yolk, isinglass and animal skin glue. In practice, casein is the most suitable, because the dried paint film remains slightly porous, allowing the mortar structure below to breathe. If a continuous film is applied over mortar/intonaco, this closes off air circulation and increases the possibility of damp/moisture causing faults in the structure. Moisture usually shows on the surface of the painting, where residues (usually simple mould, or mineral effervescence) gather, in the form of whitish crusts, or powdering. Casein also hardens quite well when kept away from moisture, becoming nominally moisture-resistant with age. By contrast, animal glues remain hygroscopic over time and when in contact with moisture tend to re-swell and/or attract microbes.

Protection of Fresco Paintings

In the past, frescoes were often varnished with a concoction known as “beverone”, a simple solution protein binder such as animal hide glue, egg yolk, or egg white. This was used to impart a glossy-gleam to the surface of fresco paintings, with a look similar to that of oil paint. However, with age, such applications tend to turn dark and attract dirt and dust. So much so, that the visual image is obscured, or takes on an aged “brown” appearance. The application of beverone is normally not associated with the artist, rather with later generations who undertook to protect the fresco surface with protein binder glue/varnish. Rather than periodically removing and replacing these varnishes, practice tended towards overpainting of the original beverone with yet more of the same, resulting in a disastrous build up of dust-friendly varnish.

Removal of such varnishes is also difficult, because these protein binders tend to penetrate into the porous surface of the fresco. As a consequence, when such varnishes are removed it is all too easy to take with them a portion of the fresco surface. These protein binders also become progressively harder and less easy to remove with age, especially when multiple coats have been impacted on top of each other.

In practice, if a fresco painting has been undertaken using tried and trusted techniques, it should not require any protective varnish, especially in the case of interior work. It can also be argued that the use of varnish on to fresco painting is detrimental to the aesthetic look of the finished paint surface and therefore not necessary.

Alternative Wall Painting Binders

Waterglass

An alkaline solution of potassium silicate is known as waterglass, and is used as a binding agent for pigments applied to plaster mortar. As with lime-fresco, the pigments used should be inert if possible, so that upon drying they are not affected by atmospheric pollutants. Painting with waterglass is also known as "Stereochromy" and became popular in the mid-19th century. Waterglass is sold as prepared paint, where the pigments are ready-bound in waterglass with the required filler materials for use in building decoration. For artistic purposes, it is far more suitable to take a solution of waterglass (typically 28% potassium silicate, dissolved in water) and to combine this clear binder with pigment-distilled water pastes to form a stiff paste. This mixture is left to dry back to a solid form (sets hard) and then pulverised to re-form a powder. The resultant powder is then mixed with an equal volume of waterglass and can be applied to any clean plaster surface, in fact any surface suitable for fresco painting. Perhaps the most suitable and easiest support would be the ground described for wooden panels, using a blend of casein and lime putty, with aggregates. In order to gain a better working consistency for the waterglass-pigment mix, it is sometimes necessary to include some filler material. Aluminium hydrate, finely ground glass, zinc white or fine marble dust may be used to achieve a better paint paste. However, such additions will tend to show when used with weaker or pale colours.

Prior to painting, the surface of the plaster intonaco is saturated with a very dilute solution of waterglass (10% waterglass to water) and the waterglass-pigment combination is applied into this wet/damp ground. This process aids adhesion. Upon drying, the paint layer reflects the colouring properties of the pigment, almost as if the painting were made without binder. In this sense, waterglass has the potential to show the best effects of invidual pigments. Once the painting is complete, ideally it is sprayed with another dilute solution of waterglass, the intention being to drive more of the binding medium into the porous crevices of the painting surface. Repeated spraying of waterglass is recommended to achieve complete fixing of the paint layer. The extent to which this fixing is done is connected to the porosity of the support.

Acrylic

Modern acrylic paint systems are sometimes designed for use in mural painting. These flow-formula acrylic paints are designed to brush out flat and have an equalised paint sheen (typically, satin-matt). Acrylic paints can be applied to any dirt and grease-free support, but care must be taken in the case of brick walls and plastered walls, to ensure that no moisture residue remains inside the wall. Unlike fresco, acrylic paints form a coherent, continuous film, thereby trapping any residual moisture behind the paint layer. This can become a problem if the wall support has not been adequately prepared prior to painting. Also, if damp penetrates the wall at any time, it becomes trapped behind the paint layer and can, in the worst case scenario, burst through the paint layer, causing cracking or blistering of the paint film.

When preparing walls for use with acrylic paints, it is vital to follow the manufacturers' recommendations as regards wall preparation and priming. It cannot be overstated that the correct choice of primer is vital in this instance. For example, the use of poorly bound white emulsion paint as a priming for acrylic murals is never recommended. Such emulsion paints have a much weaker binding strength than acrylic paints and may in fact shear off from the support if stressed (e.g. in contact with damp). Such emulsion paints are also prone to chalking after a period of a few years, indeed many are designed to do just that, so that they can be easily overpainted (for house decoration). By contrast, high quality acrylic primings are available which have strong binding strength and may even be formulated for use as priming for wall paintings.

Care must also be taken that the selected acrylic paint range meets the requirements of the wall. For example, if the mural is outside, check that the colours used are permanent to light, weathering and atmospheric conditions. Some pigments, such as zinc white, tend to break down in acrylic binders when exposed to prolonged weathering. Similarly, some synthetic organic pigments are much reduced in permanence to light when strongly admixed with white.

Acrylic paintings may be less permanent when situated in a damp environment. For example, a mural alongside a swimming pool may degrade more quickly when painted in acrylic than when carefully and correctly prepared with fresco. Any moisture that finds its way into the support wall will become trapped behind the acrylic paint film. For the same reason, acrylic paints are not advised for use in bathroom wall decorations.

Unlike fresco, acrylic-painted murals can be varnished without any problems. The acrylic resin varnishes may be water-diluting, or solvent-based. In both cases, they form continuous paint films which will render the dried paint film water-washable. In effect they can be used to seal the painting from atmospheric pollutants, as well as change the gloss or mattness of the dried paint film.

Brushes

One of the key tools for applying paint is the brush. Brushes come in all manner of sizes, hair types and qualities. For artists' use, brushes are required to have a finesse which may not be the case with household brushes. However, some brushes that are manufactured for the decorating trade may also be of interest to artists and should not be overlooked. Brush making follows different traditions according to the country/culture of manufacture. For example, Italian and French decorating brushes tend to be of a much higher quality than similar products made in the United Kingdom. However, many artists are unaware of this and overlook the possibility of using such brushes. As with all materials, a degree of experimentation is encouraged, and this can extend to trying out a range of brushes to ascertain the correct choice of brush for the type of work undertaken.

The manufacturing of artists' quality brushes mirrors the expertise and high standards exemplified in high quality artists' paints. As a consequence, many brushes have a high cost price to the artist. However, with careful use and maintenance, expensive brushes can be made to last for many years.

Brushes for Oil Painting

Oil painting requires brushes that have a degree of resilience. For example, hog bristle brushes will withstand abrasion on contact with the painting support and immersion in solvents such as turpentine. By contrast, softer hair brushes, such as sable or ox hair have less resistance to such applications. Nevertheless, many artists need to use soft hair brushes in oil painting, in order to create the exact mark required. The key to using brushes in connection with oil paint, is to clean and maintain them fastidiously. In this way, softer hair brushes will last longer.

Hog Bristle Brushes

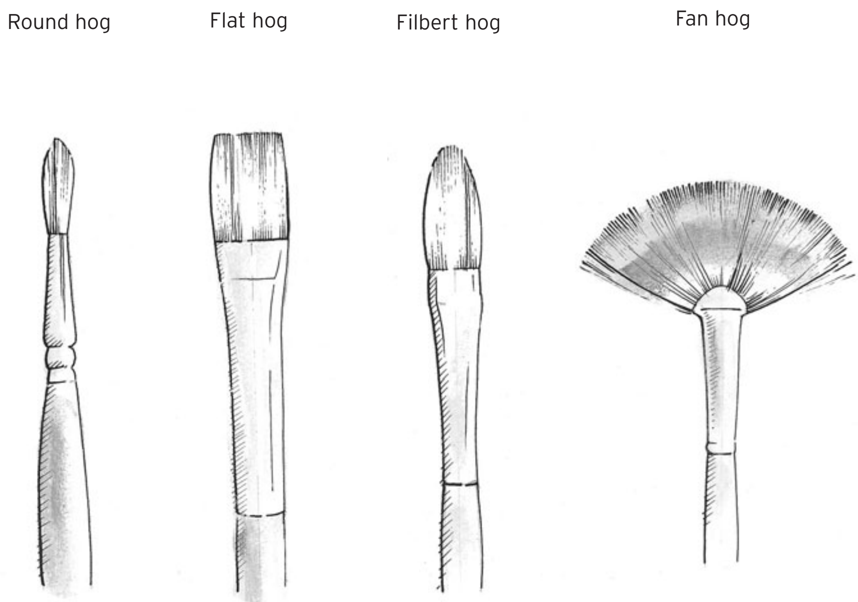
The best quality bristle brushes for oil painting are made with hair from chinese hog. The hair is carefully selected and cleaned of grease and other residues or impurities, before being shaped and fitted into the metal ring (ferrule) that clamps the brush hair on to the brush handle. The best quality hog bristle brushes will be made from specially selected hair, and the brushmaker will shape the brush tip, often by hand, to the required formation. In many cases, the work of the brushmaker is a finely honed craft, carried out by small teams of makers, or even individuals. Some European manufacturers have in recent years given their brush making over to mechanised production, which may have contributed to a lowering of quality generally in the market.

The tips of good quality hog bristle brushes are specially designed to gain a better shape during use by the artist. The hair has a minute "tree" (also known as "flags") at its tip. This "tree" of small hairs tends to grip to adjoining hairs, forming the brush tip to a coherent point. With use, these trees (or flags) associate with each other more and more, giving the brush a characteristic tip shape, which should remain constant, provided the brush is carefully washed after each use.

On first using a hog brush, often a few stray hairs may dislodge: with good quality brushes, this becomes less over time and need not be a worry. Cheaper brushes tend to continue to shed hairs and will also lose their shape. The worst kind of brush has a tip that is simply cut, rather than being carefully formed to the required shape. Such brushes will inevitably splay upon use, making controlled work impossible. Hog brushes should also be firmly packed into the metal ferrule which holds the hairs in place. If the hairs are loose in the ferrule, they are more likely to loosen further when the brush is stressed through use.

Oil painting brushes tend to have long handles, which enable the artist to stand away from the painting while working, in order to be able to judge colour mixing and make observations of the subject, etc. In most cases, the brush handle is lacquered. It would be preferable if brush handles (for all media) were made with raw wood, as quite often the lacquer from the handles splinters with time and can fall into paint pots and on to palettes, etc. However, the author has seen few examples of this type, save perhaps for brushes made for the ceramics industry.

Hog oil painting brushes are manufactured in a range of shapes: flat, long flat, round, filbert (cat's tongue) and fan. By tradition, round brushes are employed for detailed areas (with small size



Oil Painting Bristle Brushes

brushes), whereas the flat types can be used for short or long dabbing strokes. Filbert brushes, which have a characteristic tongue shape tip, are excellent for blending colour, the larger sizes offer a kind of hybrid between round and flat brushes. Fan brushes can be used for blending colours wet into wet and for gently lifting out unwanted paint applications.

Because hog brushes are relatively stiff, the marks they make tend to be rather evident in the paint film. This "gestural" type of mark may be required and has a certain aesthetic appeal. However, if one wants to lose brushmarks, softer hair brushes may be more suitable.

As with all brushes, the shape and size of the brush belly governs the amount of paint which it can hold. Many artists opt for larger round or filbert brushes to load up paint, for expressive painting. Similarly, many artists choose large round Italian house-painting brushes when needing to apply large amounts of paint. However, the larger the brush tip, the more cleaning needs to be done after painting. Typically, residual oil colour gets trapped at the base of the hair, where it fits into the ferrule. This part of the brush therefore requires particular attention when cleaning. If the paint is left in this area, it will tend to clog up the brush (make it stiffer). It may also cause the hair to splay, or stick together. As brushes are expensive, often costing more than tubes of oil colour, it makes sense to clean them regularly and carefully.

Soft Hair Brushes

For detailed or subtle applications of oil colour, softer hair brushes may be required. Included in this category, one may find brushes made with sable, ox, polecat or mongoose hair.

Ox hair brushes, made from hair obtained from the ears of cattle, give a degree of resilience yet possess great softness when used for oil painting. The hair behaves rather like sable, although it is not as soft. It has enough spring to re-form into the correct shape after proper cleaning and will help when making detailed paint marks. Ox hair brushes are supplied in a similar range of tips as with hog hair brushes, although long haired "rigger" brushes (used by sign writers) may be especially useful for applying long lines of colour and thin detailed marks. Larger size ox hair round brushes are considerably cheaper than the equivalent sable brushes and may be very useful when applying large amounts of oil colour, which then needs to be manipulated (flattened) on the painting surface. Ox hair brushes perhaps work best in connection with thinned oil colour, where the paint has been modified with an addition of oil paint medium or solvent, to create thin paint films. In glazing techniques, ox hair brushes allow paint to be applied, brushed out and then further manipulated, without revealing strident brush marks, especially when the paint medium used (e.g. dammar-stand oil) is inherently self-levelling.

Polecat and mongoose hair brushes tend to be slightly less subtle when compared to ox, although this can vary from one manufacturer to another.

Sable hair is often considered to be too soft for use with oil paint, especially when applied to linen canvas with a pronounced weave texture. Such brushes will tend to wear down quickly. However, if paint is applied in loose glazes, where the paint has been modified with the addition of a paint medium, the paint mixture will slip gently off the brush tip on to the painting surface. Problems tend to arise when soft hair brushes are used to scrub into the painting surface. They tend to shed hairs when used in this way and the ferrules will become clogged up with paint. Sable brushes are available with long handles, for use in oil painting technique, in round, flat and filbert shapes. Some manufacturers also offer fan shaped sables, which can be extremely useful for softening and blending applied paint.

For large-scale painting, soft hair brushes made with badger hair may be useful. These are normally supplied with a flat shape, up to widths of four inches. Such brushes are referred to as "badger softeners", as they are designed for use in house painting, where scumble glazes are required to be modified after application. In Fine Art painting, they can be used for a similar purpose: to push down applied paint layers, to brush such applications out, and for blending and smudging of paint.

In practice, most artists experiment with a variety of brushes before finding an adequate group of brushes to form a kind of reliable armoury.

Cleaning Brushes After Use with Oil Paint

During painting, regularly dip the brush tip into vegetable oil, or Vaseline oil. This will free unwanted paint from the brush hairs. Any residue can be carefully wiped from the brush with soft rag or paper.

Take care not to immerse brushes into solvent unless absolutely necessary, as such contact tends to make natural brush hairs embrittle over time. Vegetable oil or Vaseline (mineral) oil will suffice for cleaning. For strong staining colours such as phthalocyanine blue, repeated cleansing may be called for. In an ideal world, artists would have a complete range of brushes to match the colours on their palette.

At the end of the painting session, brushes can be completely washed and thereby maintained, by immersing into a warm solution of olive oil soap (also known as Marseilles soap). This vegetable soap restores natural oils to bristle brushes (and to soft hair brushes) and will also free residual paint from around the ferrule. During cleaning, the brush tip is worked against the palm of the hand, in a soapy lather. The author has found it useful to wear disposable latex gloves when doing this, both to protect hands and also to facilitate the washing process. After cleaning with this soap, brushes need to be rinsed with warm (not hot) water, then left to dry out completely before re-use. If the brush has lost its shape, the soap can be used to re-shape the tip. Leave to dry after re-forming, then wash through with warm water after 2-3 days.

The soap is available in grated flakes, which form a solution when mixed with water from a boiled kettle, to make a soupy gel. Alternatively, olive oil soap is available in block form, which releases a soapy lather when in contact with warm water. While olive oil soap works best in connection with oil paint, it can also be used to wash brushes after painting with acrylic, for watercolour brushes after using strong staining colours, or to clean palettes, hands, wrists, etc.

Brushes for Acrylic Painting

The same hog brushes used for oil painting can easily be transferred into acrylic painting, although they tend to reveal brush marks to a greater degree than with oil colour.

The hairs of hog brushes tend to splay more with thick acrylic paint, when paint residue gets trapped in the base of the hairs where they meet the metal ferrule. As a consequence, it is essential to clean brushes thoroughly after each colour application. With hog hair, staining colours such as the synthetic organic pigments tend to discolour the brush hairs. This can mean that cleaning is difficult and one may have to be content to have permanently tinted brush hairs.

Perhaps the best policy with brushes when using acrylic paint, is always to add a little water to the paint mixture: this keeps the paint slightly fluid, so that it comes away from brush hairs more easily. This applies particularly to soft hair brushes such as sable and ox hair. Careful cleaning, using olive oil soap will also help to thoroughly clean and shape brushes after use.

Special brushes made with a synthetic filament are available and may be most appropriate for use with acrylic paints. These synthetic (a form of nylon) brushes tend to have a softness akin to sable brushes but are slightly more snappy or springy. Brush manufacturing has developed steadily in the area of artists' brushes, so much so that today synthetic hair brushes can be designed for specific applications. For example, round synthetic brushes can be made that mimic the performance of natural sable hair but which are much easier to clean, and in the case of acrylic paints, provide brushes that are much more resilient. Some synthetic brushes tend to splay when in contact with very hot water: as with all brushes, use olive oil soap in a gently warm soapy solution to gain optimum cleaning results.

Some synthetic brushes are specifically made for use with acrylic paint: they tend to have similar handling qualities to hog oil painting brushes in that the brush tips are formed into shapes that are retained and even improved with use. Synthetic brushes are usually a white colour when first manufactured, but then tinted to take on the appearance of natural hair. Sometimes, synthetic hair is admixed with sable or other natural hairs, to make a kind of hybrid brush. These may offer a good alternative to sable brushes, because they will possess a similar softness and suppleness.

The dilution or admixture of acrylic paint with paint medium can govern the way in which paint flows off the brush. It is important to make tests with brushes on to a variety of support surfaces, prior to painting, in order to ascertain the best dilution for a paint mixture. For example, a fluid acrylic paint usually flows well without the need for extra dilution with water. The brush chosen to apply such mixtures should conform to the paint effect desired. For example, a large flat synthetic hair varnish brush may work very well when applying large areas of flat colour where the paint has been slightly diluted with a mix of paint medium and water. The shape and density of the brush hairs will govern how the paint runs off the brush. As with hog hair varnish brushes, if the hair is shaped (rather than just cut) at the tip, it will assist in laying down flat glazes.

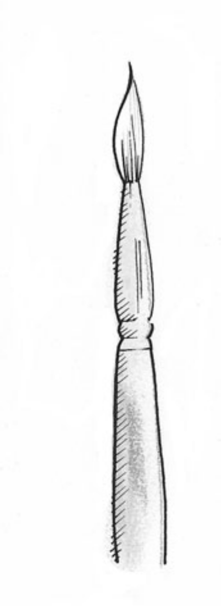
Because acrylic paint is water-diluted, care needs to be taken that the ferrules of brushes are not left in water pots for too long, as this may cause rusting of these metal parts. Perhaps the most useful brushes with acrylic paint are string bound fresco brushes, which are commonly available in Italy. The string binding allows the brush to be left in water to soak for long periods without deterioration. These brushes tend to be made with chinese hog hair and are offered in various sizes in round format, or in long, tapered ("Riga") round format.

Brushes for Watercolour Painting

Watercolour painting relies strongly on the application of diluted paint on to semi-absorbent paper surfaces. The way in which the brush contacts with the paper can be crucial. As a consequence, the choice of brush becomes integral to the type of mark required. The best brushes for applying even flat washes of dilute paint are those made with very soft natural hair, such as sable.

Sable is often cited as being the best type of natural hair because it is both strong yet supple. It has a natural spring or "snap" which enables the brush tip to re-form readily after use. The best quality sable brushes are made from the hair of sable animals living in the coldest parts of Russia. In fact, the colder the conditions, the better the hair quality. Sable can be divided into two distinct categories in terms of quality:

1. Kolinsky sable.
2. Red sable.



Round Kolinsky
Sable Brush

Kolinsky sable brushes are made with hair taken from the tails of the kolinsky, a type of mink, similar to the marten or weasel. The name is derived from the region of Kola in north-east Russia where they originate. The hair is a warm red-yellow colour. It is cut from the tail, then sorted into different lengths, before cleansing, degreasing and removal of impurities. It is then sold through special agencies to brushmakers. The price of kolinsky sable is relatively high, partly due to the scarcity of the material but also because the length of the hair (up to 2 inches or more) allows for the production of rather large brush tips. The best hair is taken by the brush manufacturer, skilfully inserted into the ferrule and crimped. The main skill here is to shape the hair without resorting to cutting it. Each hair is teased until it forms a perfect shape for the desired brush tip. The best type of watercolour brush will fit tightly into the ferrule and possess a full "belly" (the main body of the brush), tapering down to a perfect pointed tip, in the case of round brushes.

The full belly of hair allows paint to be held in this "reservoir" and then slowly released as it contacts with the paper surface. The brush tip, when wet, retains a certain degree of spring and shape during application. When the painting is finished, clean the brush in cold water, rinsing thoroughly. Afterwards, the brush can be re-pointed by quickly flicking it while it is loaded with water. This should bring the brush hair back to a perfect shape.

Cheaper sable brushes tend to remain slack or floppy under this test. Many art supply stores fear the moment when watercolour painters enter their premises to test their sable brushes, requesting a pot of water and the finest no.14 sable. However, because these expensive brushes are hand-formed, one may differ in quality to another, even within the same brand. As a consequence, it is essential for the discerning artist to test their brushes prior to purchase. Kolinsky sables are sold in sizes ranging from 5/0 (very fine) up to size no.12 or no.14 (United Kingdom sizes).

Cheaper sable brushes are often sold as "red sable" or "selected red sable". These may be from the same animal or from other animals of the same group, but the hairs tend to have less spring and snap. However, the larger sizes of these brushes may be an adequate alternative for the beginner. Some red sable brushes also include mixed hairs, for example, an inclusion of ox hair, which again will lessen the working properties of the brush.

While round sables are essential for most watercolour artists, sable brushes are also available in flat "one-stroke" format, or flat "varnish" format. Both types are useful for laying down large areas of flat colour wash.

In order to stop moths from attacking sable hair, the best quality brushes are sold with a protective sachet of camphor. Sable brushes should be left to dry hanging down if possible (so that all water drains down, rather than gathering in the ferrule), and allowed to dry out thoroughly before being stored flat, alongside a sachet of camphor for safe-keeping. If the brush is properly cleansed after each use and carefully stored afterwards, it should last for many decades.

"Sable spotters" or "retouching brushes" can be used for fine detailed painting. These are designed specifically for in-painting and retouching in the restoration of paintings. However, the watercolourist, especially botanical artists and miniaturists will find these brushes very useful. In this format, the brush has a reasonable belly but a short point. These brushes are generally sold in sizes from 00000 (smallest) up to size 6 or 8.

Flat sable brushes are much sought after by watercolour painters. These are known as “one strokes” and are fine for laying in horizontal and vertical strokes: to bring a horizontal wet wash down the paper for example.

Long hair sable brushes are sometimes useful for laying in long strokes of colour. These “rigger” type brushes frequently have long handles (which may need to be cut down). French and English quill sables have this longer hair and are fitted into shorter handles. Italian brush makers produce a compromise brush, usually in cheaper ox hair, with a very fat belly, from which a grouping of longer hair emerges. The colour is stored up in the belly and drawn out through the longer hairs to make long, thin lines of paint. Italian brushmakers also produce regular round tipped brushes (similar to round sables) in ox hair. These offer an alternative to expensive sables.

Flat ox hair brushes are also popular for laying in washes, being available in widths up to 100mm across. For laying in even larger washes, goat hair “hake” brushes can be used. These originate from Japan and China and have even softer hair, which makes them good for working wet into wet, moving colour about across the paper surface gently. These brushes are generally string bound rather than ferrule bound and their pure white hair is quickly stained by certain strong synthetic organic colours.

Squirrel hair mops, frequently fixed into place with an old-fashioned “quill” ferrule, make a good alternative to large size sable wash brushes. They are not quite as firm and able to retain their shape but they hold a good amount of liquid, so can be very useful for carrying large washes.

Synthetic hair based on a variation of nylon is often used in place of the expensive sable brushes, or in mixtures with sable. The synthetic hair is generally coloured to imitate sable and has good control and pointing. The main advantage of these brushes seems to be that they are easy to clean and very durable compared with natural hair brushes. They are also inexpensive when compared to some sables.

Brushes for Gouache Painting

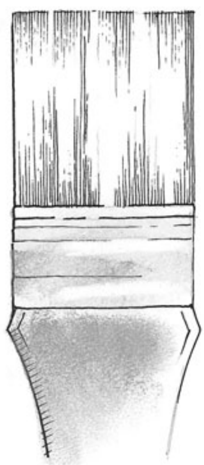
Because gouache contains some extra filler/inert white, it tends to wear down soft hair brushes more than watercolour. As a consequence, sable brushes should be employed with care. A better option may be to use synthetic (nylon) brushes, which are more resilient, or ox hair brushes, which are still soft but stand up to such vigorous use. As with watercolour, a good selection of round brushes is essential, but it is also very useful to have some flat (one-stroke) brushes, for laying in flat areas of colour. One can use flat varnish brushes, made with soft hog hair, or ox or squirrel hair for this purpose.

When the painting session is over, wash brushes carefully. Because gouache contains some extra filler/inert white, this tends to get lodged in the base of the brush hair, where it meets the ferrule. If this is not carefully washed out while the hairs are still damp, it can cause them to splay.

Brushes for Priming

When applying coats of sizing or priming to canvas and boards, it is vital to use brushes that will help to transmit the fluid on to the surface of the support. Flat brushes that are carefully shaped at the tip, give an even distribution of paint, whereas brushes with cut ends will tend to deposit paint too quickly. The ideal brush for priming is one that slowly releases the liquid paint mix on to the support surface, assisting the formation of an even coating. Correct dilution of the sizing/priming is also important. Manufactured brands tend to show a variety of consistencies: if the chosen primer is thick, then dilution with water (in the case of acrylic primer) is necessary to achieve a consistency similar to single cream. It is better to apply multiple coats of thin primer/size, than to deposit heavy, dragging coats, which tend to show up imperfections within the weave of painting fabrics. When priming layers are being applied, a first coat of size (with acrylic primer, one must only ever use an acrylic sizing) is advisable, in order to equalise the surface of the painting fabric. This is less important when applying size to boards, although dilution usually results in a more even application of the sizing material.

The dilution of sizing and primer material needs to be matched to the relative softness of the brush used. For acrylic-based sizing and priming materials, hog varnish brushes, perhaps 2-3 inches wide are recommended. The best quality brushes have shaped tips rather than cut tips and allow paint films to be laid down carefully and evenly. While these brushes are designed for the application of varnish coats, they also work very well for applying coats of sizing and primer. Softer brushes, such as flat brushes made with ox hair may also be useful when trying to achieve a very smooth surface, but the suppleness of these brushes will require the sizing/primer used to be strongly diluted, to stop the paint from dragging. Similarly, synthetic hair brushes tend to flop when used with primer, quickly losing their shape. The thickness of the brush used for priming is also of consequence. For example, brushes with a thickness of more than 5mm may quickly collect primer residue, causing the hairs to splay or the brush hair body to bulge in the ferrule.



Flat Hog Varnish/Priming Brush

Because primers tend to contain chalk in their make-up, it is wise to wash brushes immediately after use, rather than leaving them to stand in water. If brushes are not completely cleaned, some residue of priming can collect at the base of the hair, where it fits into the metal ferrule. These ferrules will also begin to rust when left standing in water, although some brands are made with non-rusting ferrules. In any case, it is not advised to leave brushes standing in water, as prolonged immersion may affect the glue used to fix the base of the hairs on to the paint brush handle.

Hog hair varnish brushes are available in sizes from $^{1}/_{2}$" inch to 4", although larger widths may also be available, up to 6 or 8 inches wide. These wider brushes tend to give less control than the smaller widths when applying primers, simply because the $^{1}/_{2}$ hand is more prone to wavering when applying the material to the support. It is important to retain control over the brush and its contents when applying sizing/priming, as an even application is crucial to a smooth finish. The brush is held at about a 45° angle against the support and then slowly worked in one direction over the support surface. By diluting the material so that it runs slowly but freely off the brush tip, an even coating is easier to obtain. However, careful brushing after application will help to squash down the sizing/primer, so achieving an even finish. While the sizing/primer is still wet on the surface, further brushing can be effected: working the brush in one direction, then leaving to dry. The next coat can then be applied with the opposite right-angled stroke, and subsequent coats varied in a similar fashion.

Brushes for Varnishing

When applying coats of varnish to dried oil paintings and dried acrylic paintings, a simple hog varnish brush, as previously described, should suffice. Varnishes for oil paintings tend to be sold ready-diluted for application, and will have a consistency similar to milk. Before applying, some tests should be undertaken on to a similar support, to see how easily the varnish brushes out. If the varnish drags, it can be diluted a little with the same solvent used in its manufacture (e.g. ketone resin tends to be solved into white spirit, so use white spirit). Water-based acrylic varnishes tend to be slightly thicker, typically a little thicker than single cream. With these varnishes, a degree of dilution may also be required in order for the varnish mixture to slip off the brush.

As with priming, the brush needs to be cleaned after each use, so that it remains supple and retains its shape. Hog varnish brushes should be cleaned with olive oil soap, followed by a thorough rinsing with warm water. If possible, the brush should then be hung, with the hairs facing down, so that any paint residue falls down and out of the hairs. Often these brushes have a small hole in the handle to allow them to be hung in this way.

Brushes for Soft Pastels

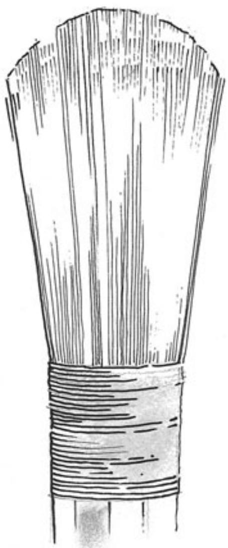
Although pastel is applied directly to the painting support, special soft brushes can be used to distribute and manipulate colour once it has been applied to the painting surface. Keep the brush hairs dry at all times, using soft strokes to mix, fuse and blend colours with gentle pressure only. Suitable brushes may be those made with squirrel hair (e.g. squirrel mops), pony hair, mongoose hair, ox hair or sable hair. If this technique proves successful, it may be prudent to keep a number of brushes to hand, so that basic colours can be dealt with separately.

Brushes for Fresco Painting

Fresco painting requires the use of special brushes, which allow for a degree of control while at the same time being resilient. By tradition, string bound brushes are used, so that the brush can be kept wet while not in use, by depositing in a bucket of water. In this way, the brush hair does not dry out and become brittle and any residual lime in the hairs slowly soaks off while immersed in water. Some metal ferrules may have resistance to rusting when placed in water, if handled with care, so ferrule bound brushes may also be used for fresco painting.

Traditional fresco brushes are made with white chinese hog hair, in two distinct formats:

1. **Muccino - round shape.**
2. **Riga - long round shape, with tapered tip.**



String Bound "Muccino" Fresco Brush

Storage and Preservation of Finished Artworks

When handling works of art, for example, when bringing them in and out of storage, it is a good idea to wear some soft cotton (lint-free) gloves. These will stop greasy finger mark residues and also encourage the wearer to take extra special care. This could be vital when moving larger works, or delicate paintings (e.g. pastel on to paper).

Oil Paintings

The ideal drying place for a finished oil painting, is to be hung high up on a wall (above dust levels), facing out, so that the paint surface receives daylight. However, this daylight should not be direct (i.e. not in a south facing window). Paintings that are left to dry in such a position tend not to yellow excessively, especially when they have been left to dry for six months or more in such a position. By contrast, newly finished paintings that are immediately stacked away from light, or in a closed dark room or cupboard, will show yellowing (darkening) much sooner. The quality of paint used may also have some bearing on the yellowing/darkening of a paint film. Cheaper paints, which often include too much oil in their composition, will show yellowing, whereas higher quality products tend not to. Hand-made oil paints will always have a tendency to yellow, simply because the incorporation of oil to pigment is not done in a specific measured way. As a consequence, paintings made with hand-milled colour should ideally be exposed to light upon completion. Paintings that have yellowed can be restored to some degree by facing into direct sunlight for a period: some aspect of the darkening of the paint film may be rectified, as the oil film is gently bleached by sunlight. However, such treatment can never return for example, a passage of white paint back to being a pure white area.

The use of paint mediums may also contribute towards the darkening of oil paint films, especially when large additions of such mediums have been made. For example, alkyd resins can cause a darkening of the paint film when used in concentrations above 10%, especially when added to whites or pale colours. Similarly, the natural resins dammar and mastic, both of which are commonly used in painting mediums, are known to darken over time to some extent.

To a degree, this darkening of the paint film can be accepted, because it reveals a natural patination/ageing of oil paintings. In the auction house, this aspect is highly prized: old oil paintings can reach higher prices at auction when they show this characteristic "aged" appearance. For the artist, such inevitable chemical changes within the oil paint film may compromise the appearance of the image. In order to minimise the natural darkening of oil paints, it is therefore vital to adhere to good practice while painting, especially in the judicious addition of oil paint mediums. It is recommended that before using an oil paint medium, some aspects of the properties of the component parts are understood. For example, beeswax may impart a beautiful sheen to oil colours, but it also leaves the paint film matt (attractive to dust) and vulnerable to heat (the wax can re-melt if exposed to strong heat). These properties must be understood before the decision to use this is taken.

Many artists assume that the varnishing of dried oil paintings is essential. However, if a small addition of a paint medium has been used during painting, it may be completely unnecessary to apply a final picture varnish. Doing so would only alter the appearance of the painting and may make it too gloss, or too matt, depending on the type of varnish applied. Varnishes can also cause more harm than good. The solvent content of a varnish can percolate into recently dried (or still drying) oil paint layers. In the worst case scenario, the solvent reconstitutes the paint layer, causing bleeding from one layer to another. Applying a layer of varnish over paint that appears to be dry (but is in fact only touch dry on the surface) may cause eventual cracking, when the paint film completely dries out. Applications of varnish may also cause a colour change in the appearance of the painting. The natural resin varnishes (dammar, mastic) turn yellow-brown after many years, giving a dark film over the painting surface, which may obscure details in the painting. Also, some natural resin varnishes, notably dammar, stay slightly tacky on the surface, attracting dirt and dust.

When a dried oil painting is stored or is to be shipped, it may be appropriate to protect the painting. For shipping, ideally oil paintings are crated in wooden boxes, specially built for this purpose. Avoid wrapping an oil painting if at all possible. If a dried painting has to be wrapped (for example when being stored), thick polythene sheeting may be used with some caution. If the paint film is even mildy soft, it may adhere to the sheeting, causing damage. It is important to avoid using bubble-wrap-plastic, as the air-filled pockets tend to adhere to oil paint surfaces, even when seemingly completely dry. This is especially so in the case of oil paintings with additions of paint medium, for example dammar-stand oil medium. The dammar remains slightly soft and a little tacky and will want to adhere to other surfaces. In the case of bubble-wrap, the pattern of the bubbles is often transferred on to the paint film. If paintings need to be rolled to be shipped, cracking may result. The painting must be rolled with the paint surface facing out, to minimise contraction. As wide a cardboard roll as possible should be used (e.g. a carpet roll), with the painting being faced with acid-free tissue paper, or glassine paper as it is rolled. If a painting is rolled soon after completion and drying, it tends to resist cracks: by contrast, older oil paintings become increasingly harder with time, and when rolled can crack easily, especially where impasto areas of paint are present. Paintings that have been varnished may also crack more easily, as the varnish film may have less flexibility than the paint layers.

Oil paintings need to be stored in ambient temperature conditions. Never store paintings in damp, or excessively cold rooms. This is especially important when the painting has sizing made with an animal glue. Such glues remain moisture sensitive and will soften in damp or humid conditions, often resulting in mould growth, and/or changes in tension on the painting fabric. Damp and humidity may also cause rusting of staples or tacks used to fix the painting fabric to the support. Paintings made on to wooden panels must also be kept away from sources of moisture to prevent warping.

Acrylic Paintings

High quality acrylic paints remain flexible upon drying and may be safely rolled with care. However, acrylic paintings made with heavy impasto may have reduced flexibility. Hand-made acrylic paints may also have reduced flexibility, especially when heavy applications have been made, or where there are inclusions of gritty materials. Paintings made with heavy gels or texture pastes can also lose adhesion to the support if rolled.

Acrylic paintings, once dried, are virtually impervious to water. As a consequence, dust and dirt can be gently cleaned from the surface of the painting, by treating with a very mild detergent and a lint-free cotton cloth. Often, it is enough simply to dust the surface of the painting. Never clean acrylic paintings with alcohol, or any product that contains alcohol, as this will re-swell the acrylic paint film, causing blisters or cracking.

Works on Paper

Watercolours and gouache paintings made on to paper should be stored in closed portfolios, away from sources of direct sunlight. Similarly, framed paintings should be hung on walls that receive a diffused or subdued light source. This is especially so in the case of watercolours made using pigments with reduced permanence (e.g. plant-based pigments such as madder). Avoid hanging works of art on paper in direct sunlight, especially in south-facing windows.

The paint film with watercolour and gouache paintings, is more liable to atmospheric pollutants than with oil or acrylic paints, where pigments are effectively locked into the binding system. As a consequence, watercolour or gouache paintings made with unstable pigments are more liable to change. For example, massicot (lead mono oxide) is a pale yellow, which quickly turns greenish or even black when exposed to air, especially when bound in gum arabic, or casein. In order to stop this rapid colour change, such pigments can only be used in binders that effectively coat and therefore protect the pigment particles. Klucel binders can be used with some success in such instances: this thick syrupy paste encapsulates the pigment particles and affords better protection to air, yet gives a similar matt-neutral sheen when dry, as standard watercolour or gouache binders.

The particular defects of certain pigments are alluded to in the pigment section: an understanding of how pigments perform in different binders can be useful, especially when using water-based paints.

Paper as a support is also not without its difficulties. It is prone to deterioration on contact with acid compounds in the air. Many papers are sold as being acid-free: that is, at the point of manufacture, they are pH balanced. However, over time their acidity can alter, depending on the environment in which they are stored. Some papers are buffered with chalk (calcium carbonate), which may help to resist the action of acid compounds. Paper is also prone to deterioration on exposure to damp, whereby mould can develop. It therefore follows, that any works of art on paper should be stored in a closed portfolio, away from damp or humidity. Contact with metals should also be avoided, where for example, rust spots can quickly develop when in contact with damp or humidity.

Pastel Paintings

Where a pastel painting has been fixed, a reduced amount of pigment dust will become dislodged if the paint surface is disturbed. However, in practice, all pastel paintings, whether fixed or not, can easily be disturbed and damaged unless carefully handled. For storage, pastel paintings can be interleaved with acid-free tissue paper, so that the delicate surface has a nominal protection. Pastel paintings are best stored flat, for example in a plan chest, away from dust and draft sources. The application of fixative may change colour values and as a consequence, fixing is normally kept to an absolute minimum.

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Society of Dyers & Colourists

Perkin House, 82 Grattan Road

Bradford, West Yorkshire BD1 2JB

England

OR

American Association of Textile Chemists and Colorists

PO Box 12215

Research Triangle Park, North Carolina 27709

USA

Useful contacts:

ASTM

1916 Race Street, Philadelphia

PA 19103-1187

USA

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