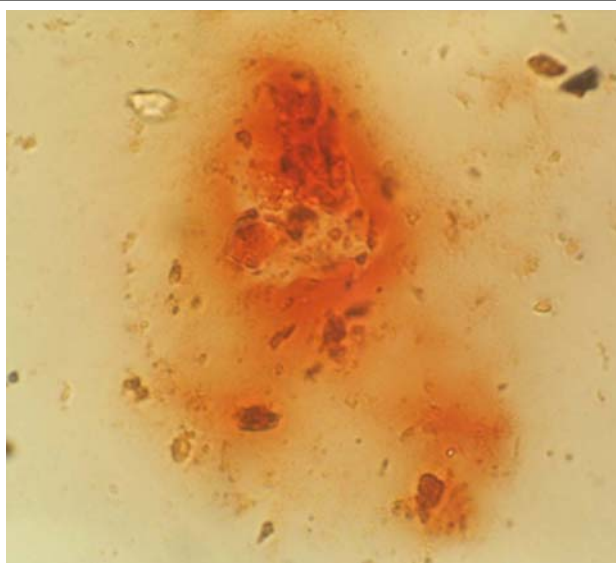


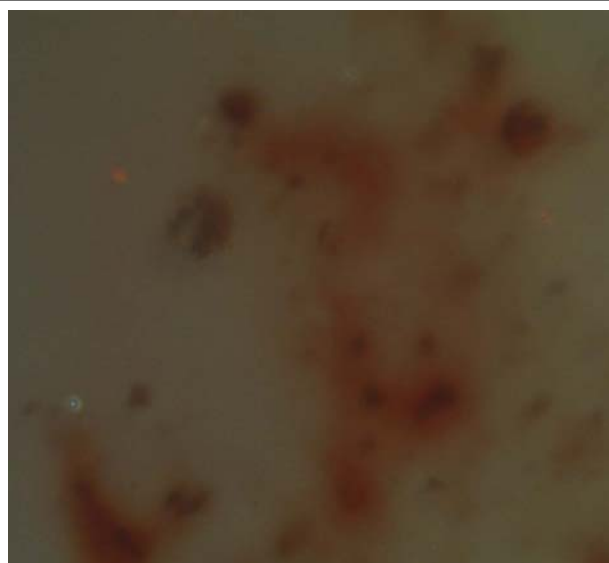
Dragons Blood

Sanguis Draconis

Shrub species *Pterocarpus draco*



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Ancient times to, less commonly, the present day.

Summary of Manufacture

A red resin extracted from the Asian trees *Calamus draco* (a rattan palm) but occasionally also attributed to the resin from the shrub *Pterocarpus draco*. The bright dry resin looks similar to dried blood which inevitably gave rise to the legend of its originating from the blood of dragons and hence the name still used today. The resin is washed, ground and worked together with an oil or water based medium.

Brief History of Usage

Originating from Asia the pigment was traded Westward and was a popular red colourant in Medieval times being known as Dragons Blood. Pliny was the first to describe the myth of its source and many mythical accounts for its origination can be found since. The fashion for rich colours found in Persian art and then in Byzantine traveled home to Europe during the Crusades and with it rich reds, blues and greens from Eastern sources. It seems it found little use in the painters palette of the seventeenth century and generally after its hey day in the Middle Ages. It was expensive to import and inevitably synthetic reds took over.

Surface Morphology / Microscopic Description

As a resinous substance particles may be difficult to isolate or identify.

It is a resin with a red/ brown surface colour changing to a red/orange hue in the center of the deposit.

Similar in appearance to cochineal and the carmine lakes, dragon's blood is more orange in hue.

Aging Characteristics

As an organic of vegetable origin it has poor permanence.

Cennino Cennini said of dragons blood 'you should leave it alone and not care for it a lot as it is not in the conditions giving you much honour.'

(<http://www.sebino.it/pigmenti/english/129.htm>)

Highly transparent and often used for glazing, for instance mixing with varnishes or glazing silver to impart a copper tone.

Soluble in ethanol.

Technical Examination Techniques/ Instrumental Analysis Techniques

Particles do not exhibit birefringence as can be seen from the samples above.

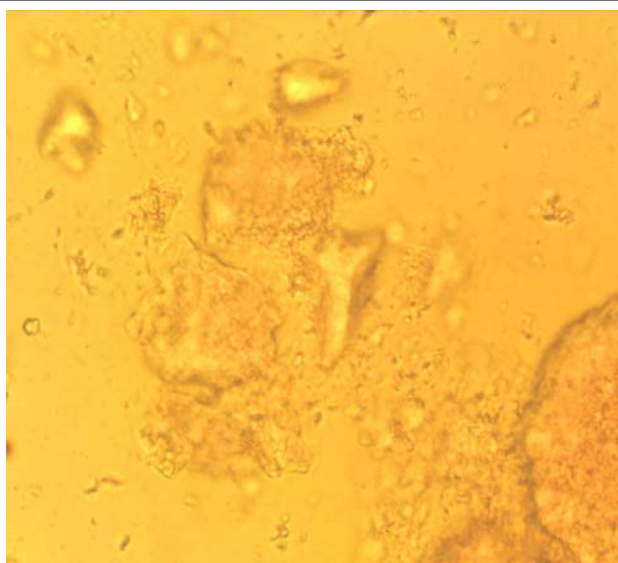
Particles themselves are difficult to see except at high magnifications.

With a magnification of x500 or less only a resinous substance will be seen which can only be confused with a carmine lake such as cochineal or kermes.

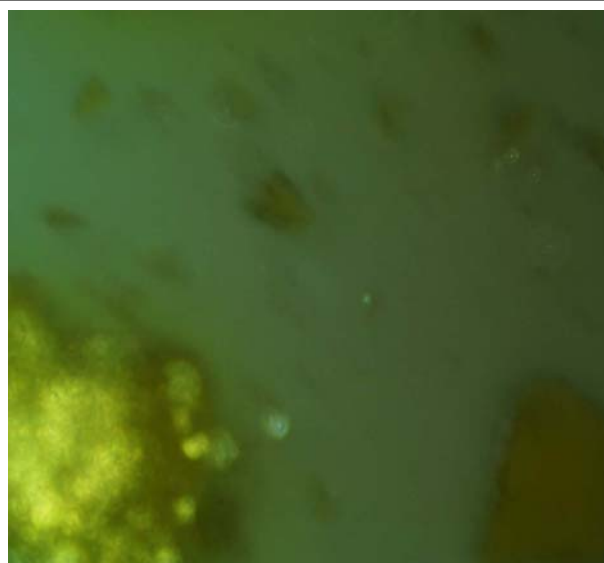
Raman microscopy & high powered liquid chromatography (HPLC) will distinguish each with standard samples.

Gambouge

(Gambogic Acid - Colouring Principle)
Yellow gum resin of particular tree species



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Since Ancient times in the Far East, spreading to the West in the 16th and 17th Centuries. Still used today.

Summary of Manufacture

Drawn from trees through incisions made in the bark. A milky juice exudes and hardens upon contact with the air. It was then sold in the form of hard yellow lumps, which are often covered in yellow dust.

Brief History of Usage

Used for centuries in the Far East in painting and quickly spread to the West as trade increased in the late 16th, 17th and 18th Centuries. Flemish painters were the first to exploit the pigment in oil paintings and importantly it was also used to impart a golden hue on the leather for which Amsterdam was famous in the 17th Century. By the 18th Century trade was such that it could be bought across Europe in lump form from the chemist. It was largely abandoned in oil painting because of its transparency but was commonly used in gold leaf and in water colours. Often mixed with Prussian Blue or Indigo to make a rich green that was known as Hooker's green. Gambouge fades however in sunlight which accounts for the blue trees, bushes etc often seen today in landscape watercolours of centuries before.

Surface Morphology / Microscopic Description

Light yellow rounded particles.

The majority of particles have a distinctive well-rounded shape but some will not conform to this description.

Crystals will appear translucent in reflected light but clearly cylindrical and yellow under cross polars

Appears as a translucent resinous exudate.

Seen to have an amorphous structure

Particles are usually between 1-50µm in size.

Gambouge = 70-80% yellow resin and 15-25% water-soluble gum. The rest is composed of esters, hydrocarbons, wax, ash residue and vegetable detritus.

Aging Characteristics

As a watercolour it is clear, highly transparent and warm yellow in hue with a medium tinting strength.

If powdered and ground in oil paint it tends to a fairly permanent medium, but in watercolour it tends to fade rapidly. Has a reputation for being soluble in everything and is partially soluble under heat in varnishes, linseed oil and gum arabic as well as in alcohol and some other organic solvents.

Unaffected however by sulphur compounds but bleached by strong heat.

Technical Examination Techniques/ Instrumental Analysis Techniques

Particles are isotropic and show characteristic intense yellow birefringence. Some small particles, however, in our sample were not birefringent in comparison to larger cakes which glowed.

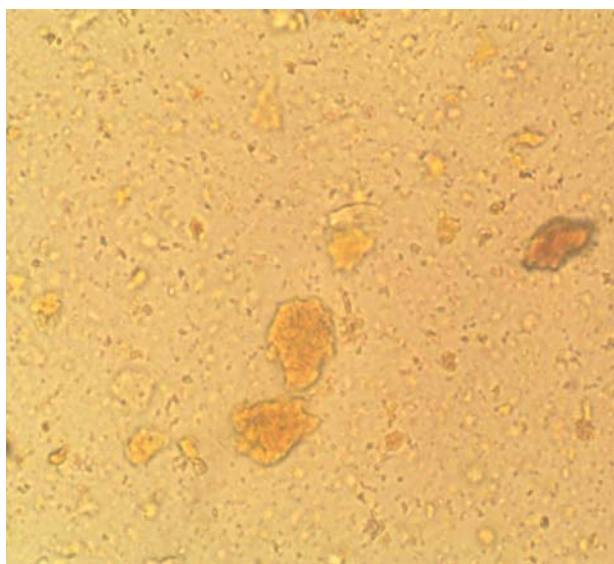
Refractive index ca. 1.58.

Test - Pigment is slowly soluble if heated in Aroclor (the pigments surface becomes globular).

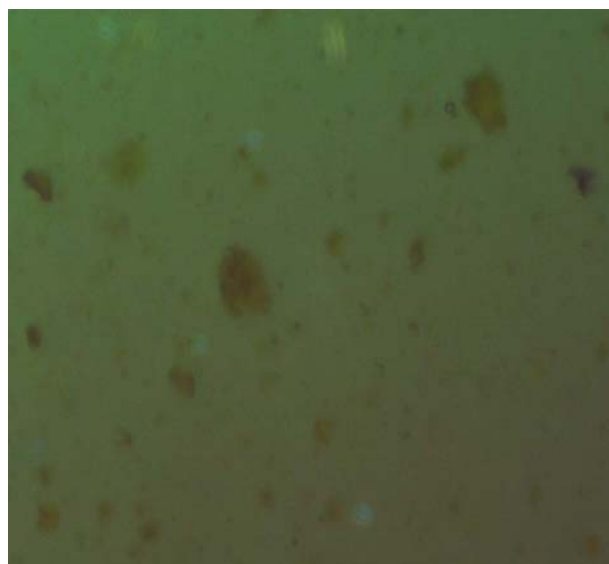
Appears bright yellow in transmitted light and absorbs ultra-violet appearing purple/ black.

Indian Yellow

$C_{19}H_{16}O_{11}Mg \cdot 5H_2O$ Magnesium or calcium euxanthate
(Alternative Names if Applicable)



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Since ancient times in the Far East, traded to Europe and banned in England in 19th Century

Summary of Manufacture

Was once produced from the sun dried urine of cows fed solely on mango leaves (*Mangifera indica* Linn) in India. It was then exported in crude lump form called piuri to Europe where it could be powdered, washed and bound with a medium for painting. The lumps were brown on the outside and brilliant yellow-green on the inside. Synthetically produced Indian Yellow is still available however today from a few suppliers.

Brief History of Usage

Known since ancient times and used in Indian miniature painting. Exported and traded in Europe in the 18th Century but disfavoured in England in the late 19th Century when the truth about its manufacture was finally uncovered.. Its production was finally prohibited in 1908 on humane grounds since mango leaves are harmful to cattle. Commonly seen in Indian miniatures. Found in European palettes from the 18th Century, particularly in water colours.

Surface Morphology / Microscopic Description

Yellow crystalline particles with a deep rich, translucent orange/ yellow hue. Anisotropic and exhibiting weak birefringence.

The coloring matter is principally the magnesium or calcium salt of euxanthic acid, $C_{19}H_{16}O_{11}Mg \cdot 5H_2O$.

Particles can vary greatly in shape depending upon their manufacture from rods to spherulite to appearing like a gel.

Particles can vary in size from 1-30 μm .

Aging Characteristics

With a low hiding power and good tinting strength it was used in both oils and water based mediums because of its good lightfastness. Although direct sunlight will result in slight photooxidation and therefore fading. The colour is discharged in excess aqueous acid and may be regenerated by aqueous alkalinity. It is only slightly soluble in water and is decomposed by hydrochloric acid with precipitation of white euxanthic acid.

Technical Examination Techniques/ Instrumental Analysis Techniques

All Indian yellows are moderately birefringent

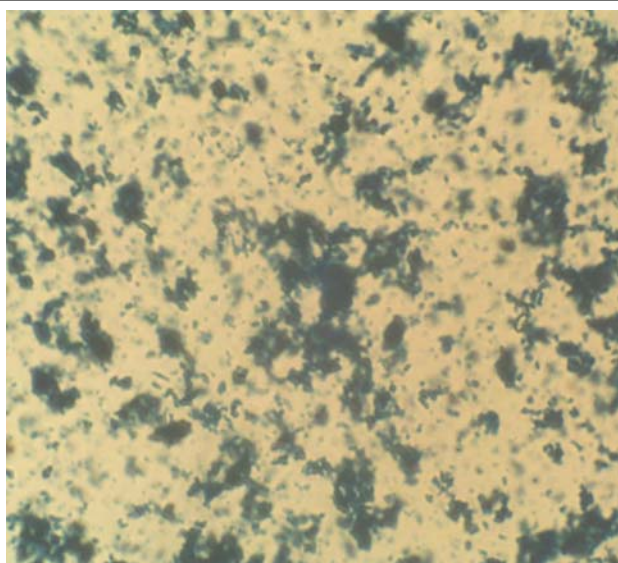
Particles exhibit extinction although the type of extinction can vary from sample to sample.

Exhibits strong bright yellow fluorescence in ultra-violet light.

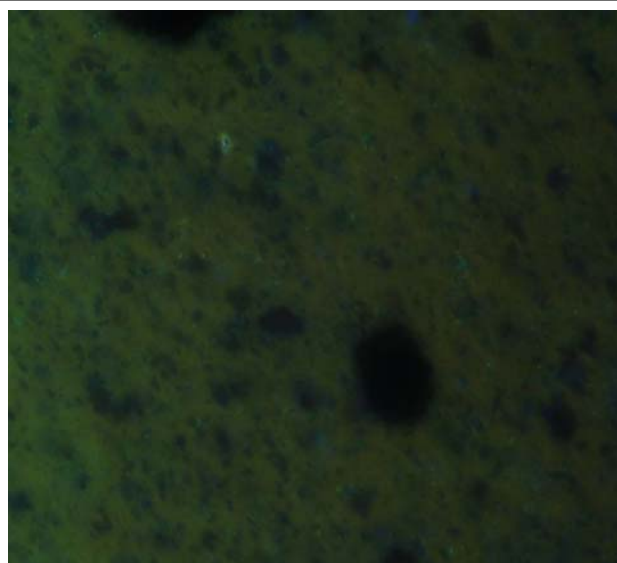
Appears clear in infra red light.

Indigo

$C_{16}H_{10}N_2O_2$ (Colouring matter - Indigotin)



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Known since Ancient times to the present day.

Summary of Manufacture

A violet blue vegetable dye derived from certain plants cultivated in India from the genus *Indigofera*, among which *I. Tinctora*, probably of Indian origin was the main source of the dye until the process of making the synthetic variety (from coal tar) was discovered by Baeyer in 1880. From the natural source preparation involved macerating the freshly cut plants, packing them into large vats and allowing them to ferment. After the glucoside is hydrolysed into indigo and sugar the dark precipitate is strained, pressed and dried into cakes.

Brief History of Usage

Earliest records have come from the Far East where it was used prolifically for dyeing cloth. It was known over Egypt and formerly grown all over the world but in particular India, China and Bengal indigo, which was one of the highest grades produced. It spread to Europe rapidly and was mentioned in the XII century in commercial trading documents. The pigment can also be found in Italian painting as early as the XV Century. Since 1900 and the invention of the synthetic variety natural indigo is rarely processed.

Surface Morphology / Microscopic Description

Deep blue, regular and slightly rounded particles.

All particles are very fine.

Some deep blue needle shaped particles often seen.

Particles are difficult to analyze and almost no distinct particles can be seen at magnification. De Wilde however, suggests that particles do appear at x1500 magnification.

Particles are usually between 1-10µm in size.

Aging Characteristics

Has a fair tinting strength but has poor permanence tending to fade in sunlight. Chemically stable being insoluble in water but soluble in hot water, ether, alcohol, lyes and hydrochloric acid. Nitric acid decomposes it with the formation of a yellow compound called 'isatin'. It is reduced by reducing agents to soluble indigo white, called 'leuco indigo'. The latter process is important to dyeing where the dye is taken up by the fibres and then oxidised by the air to soluble indigo blue. The pigment is also bleached by hypochlorite solutions.

Technical Examination Techniques/ Instrumental Analysis Techniques

Particles exhibit slight pleochroism, are anisotropic and have a very low birefringence.

Transmission colours with the Chelsea Filter = varies from a dark blue to a red/ violet.

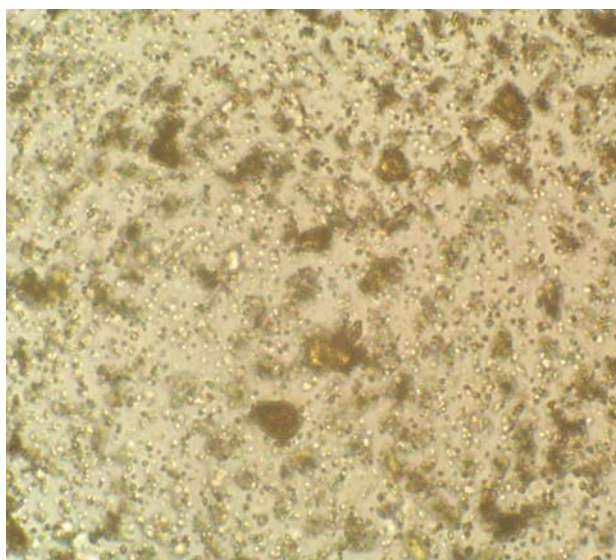
Sublimes when heated to 300°C. Refractive index of >1.66

Looks grey under infra-red, very dark under IR False Colour and dark blue under UV light.

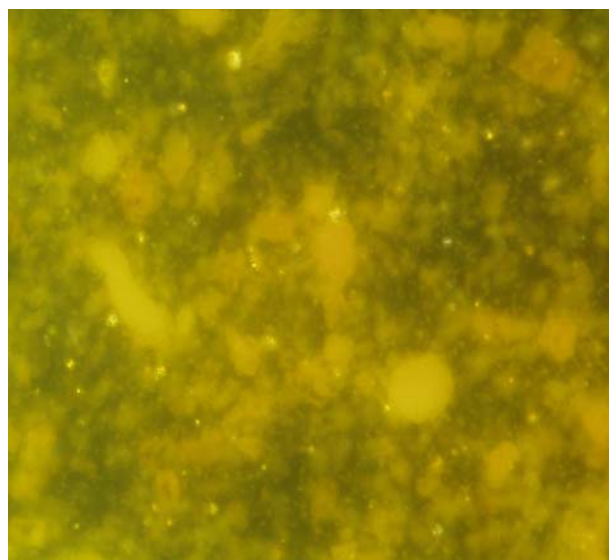
In thin films it is green and blue by transmitted light.

Naples Yellow

$(\text{Pb}_3(\text{SbO}_4)_2)$ (Lead antimonate)
Car



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Ancient times to the modern day although its history is obscure.

Summary of Manufacture

Made from the prolonged roasting of the mixed oxides of lead and antimony; or from salts of those metals, like tartar emetic (potassium antimonyl tartrate) and lead nitrate with sodium chloride.

Brief History of Usage

(Note: Genuine Naples yellow is a lead antimonate, however the paint tube colour of the same name is sometimes a substitute mixture of white and ochre, with or without an addition of red.) The name Naples yellow came to signify a shade of yellow rather than the actual source of the pigment.

Used as a colour tint in yellow ceramic glazes in Babylon and Assyria and was also found in Egyptian glass of the XIX Dynasty. It was reputedly a pigment in the palette of the Old Masters but generally its history is unsure. Up until the watercolour period its importance is undocumented. It has been essential to the landscape tradition because it has the quality of appearing to recede into the picture's distant plains unlike other yellows which sit in front of the plain.

Surface Morphology / Microscopic Description

Essentially a lead antimonate which may be considered to be chemically combined lead and antimony oxides. It varies in colour from yellow to orange depending upon its constituent chemical proportions.

Particles are homogenous and appear very fine and finely divided, similar to what you would expect from a synthetic pigment.

No crystalline form can be detected even at high magnification.

Particles are usually between 1-5µm in size.

Aging Characteristics

Its hiding power, tinting strength and drying properties are good.

Chemically it is quite stable and is little affected by alkalis, dilute or concentrated nitric or hydrochloric acids.

It fuses only at high temperature but turns dark brown permanently.

Technical Examination Techniques/ Instrumental Analysis Techniques

Particles are isotropic rounded yellow grains.

Particles do not exhibit birefringence or pleochroism.

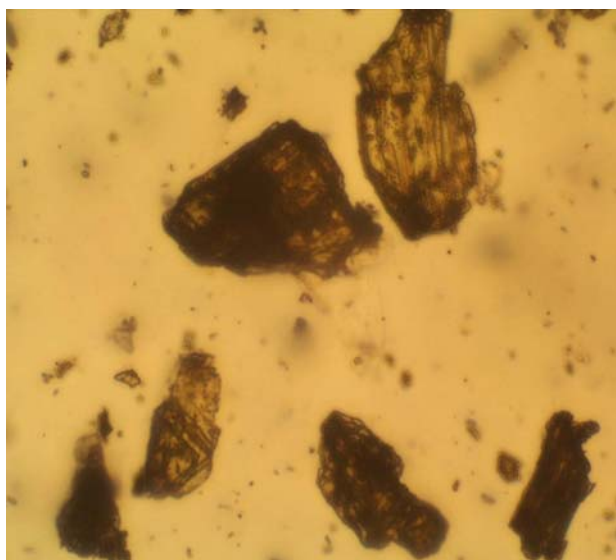
Refractive indices of 2.535 and 2.665.

Confirmed by microchemical tests for lead and antimony.

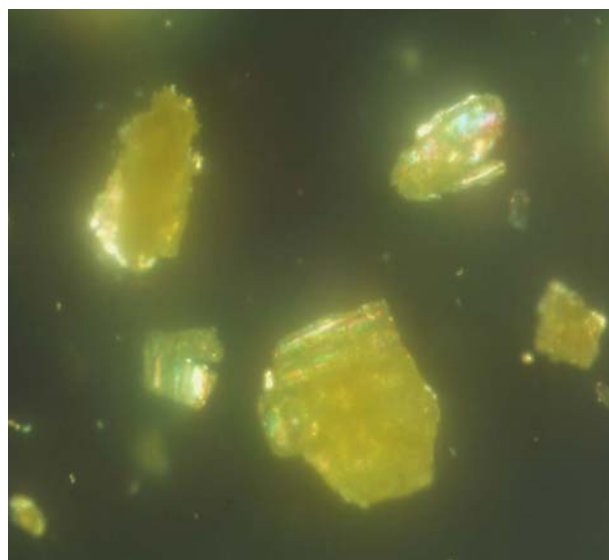
Orpiment

As_2S_3 (The yellow sulphide of arsenic)

Kings Yellow, from the latin, '*auripigmentum*' for gold/gold coloured paint



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Ancient times up until the 1900s

Summary of Manufacture

This natural sulphide occurs widely, but in relatively small deposits. Principle Ancient sources seem to have been Asia Minor, Central Asia, Macedonia and Hungary. Natural deposits were mined, ground and washed in preparation. In modern times the artificial version can be made through a process of sublimation and precipitation.

Brief History of Usage

Known to the Greeks as *arsenikon* and related to the Persian *zarnikeh* which is based on the word *zar*, the Persian for gold. Known since ancient times its export to Europe was at one time prolific with large supplies reportedly leaving the Shih-huang-Ch'ang in Yunnan province of China. Mentioned by Pliny and Vetruius and found in Egyptian works, Persian and across Asia. It seems to have had little known use in Northern Europe where lead tin yellow seems to have been one of the dominant yellows in a European palette. Orpiment, (yellow arsenic sulphide) often gets confused with Realgar (the red arsenic sulphide AsS or As_4S_4) They are similar and both have been used in their natural and synthetic forms.

Surface Morphology / Microscopic Description

Distinct brilliant yellow (rich lemon in colour) pigment, often coarsely ground to retain its vibrant hue particles are rich yellow.

Large particles may appear to have a waxy, glazed appearance.

Look for characteristic orange-red realgar particles which are often present.

Crystalline yellow cleavage fragments.

Occasionally a fibrous structure may be seen.

Particles are usually between 1-30 μm in size.

Aging Characteristics

Stable to light and air.

Unaffected by dilute alkalis and acids however reactive to strong acids.

Burns when ignited to form arsenic trioxide.

As a sulphide it is reactive with copper and often, lead based pigments.

Technical Examination Techniques/ Instrumental Analysis Techniques

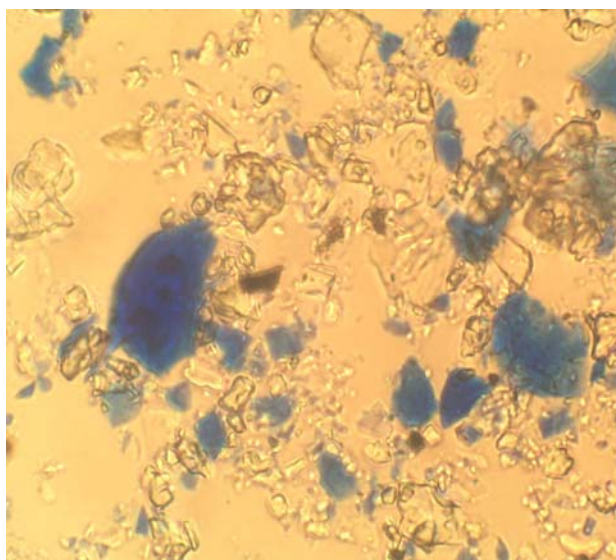
Particles exhibit anomalous polarization colours, high birefringence and complete extinction.

Has a very high refractive indices.

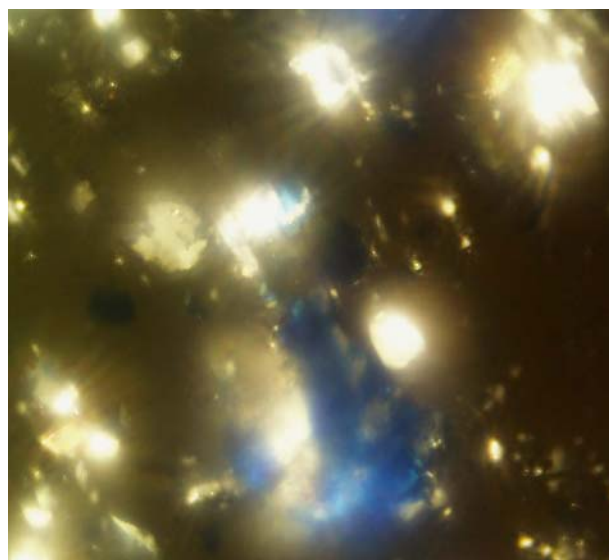
Confirmed by microchemical tests for As and H_2S evolution.

Ultramarine

$\text{Na}_{8-10}\text{Al}_6\text{Si}_6\text{O}_{24}\text{S}_2-4$ From the semi-precious stone - **Lapis Lazuli**
A mixture of the blue mineral lazurite, calcspar and iron pyrites



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Ancient times in the East, from Medieval period to modern day in the West.

Summary of Manufacture

There have been many documented methods for its preparation one is summarised as follows;

"Choose a rich blue stone. Pound it in a bronze mortar and sift. Melt the powder in 6 ounces of gum mastic and 3 ounces of new wax per pound of lapis. Work the resulting ball for a few days. The blue particles are extracted by the addition of lye and the ball kneaded like bread to extract them. The first particles of pigment 'given up' by the kneading are the purest. Cennini Cennino (1437)"To Purify Ultramarine' from the Craftsman's Handbook.

Brief History of Usage

Ancient sources are said to include Persia, Tibet and China; and is believed to have been brought to Europe in medieval times from Badakshan mines originating in Afganistan. At one time it was more expensive than gold and although traded in the medieval period to Europe it has in fact been found in earlier works in England and France in the 12th Century and the year 1000 respectively.

Surface Morphology / Microscopic Description

Conchoidal blue flakes.

(Synthetic - Tiny rounded blue grains)

Particles size can vary greatly however depending upon the extent and skill in preparation.

Microscopically it is extremely difficult to tell apart from the synthetic French ultramarine. However, as you would expect, synthetic particles tend to be more uniform and finely divided.

Particles are usually between 1-50µm in size.

Aging Characteristics

(Note: A close approximation of this colour can be obtained by mixing Phthalocyanine blue and white.)

Technical Examination Techniques/ Instrumental Analysis Techniques

Particles are isotropic and exhibit **high colourless birefringence.???? McCrone says no birefringence!**

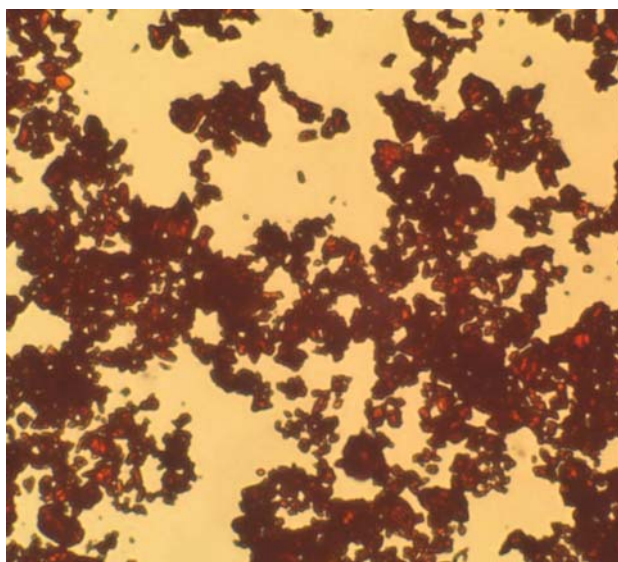
Transmission colours with the Chelsea Filter = Bright red..

Looks semi-transparent under infra-red light, red in IR False colour and blue under ultra-violet light.

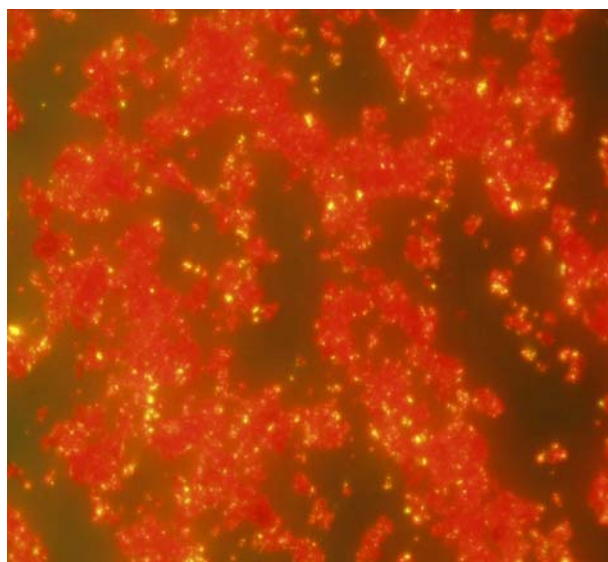
See Appendices for chemical spot test for ultramarine (caveat: result will be the same for synthetic French ultramarine).

Vermilion

HgS (Red mercuric sulphide)
Cinnabar



Microscopic appearance at x500 mag



Microscopic appearance under slightly crossed polars

Dates of Use

Known and used in China since prehistoric times, it spread across Europe and was the principle red in painting until the manufacture of its synthetic equivalent, cadmium red in .

Summary of Manufacture

The natural deposits of cinnebar, the principle ore of mercury, was crushed and ground in early history. Two methods however emerged in its manufacture; that of the dry method, which was used by Ancient alchemists and the wet method, which was developed in England, Germany and America.

Brief History of Usage

Used in China since Ancient times and found on cartouches, stamp seals, silk and scrolls. The pigment was known to the Greeks and Romans and was mentioned by Pliny who called it 'minium'. According to Pliny the whole supply of vermilion came from Sisapo in Spain. The pigment quickly spread Westward and was used up until the discovery of cadmium red, when its use dramatically reduced due to its known blackening upon reaction to hydrogen sulphides in the air. The main source is Almaden, Spain but deposits can also be found across Europe, China, Japan, California, Mexico and Peru.

Surface Morphology / Microscopic Description

Artificial cinnebar does not differ chemically or physically from the natural ore but manufactured vermilion tends to have finer, more uniform particles. Course and broken shard particles are more likely to be natural. The particles are highly birefracting ($n_{Li} = 3.14$, $n_{Ti} = 2.81$).

Particles manufactured by the wet process appear as tiny, homogenous particles.

They are evenly separated, transparent with a glassy appearance and light red in colour.

Particles are usually between 1-30 μ m in size.

Aging Characteristics

Vermilion is, largely, a permanent pigment, its body and hiding power are stronger than those of cadmium red. However in the presence of hydrogen sulphides and sunlight the pigment reacts chemically darkening to a black physically. Although it is a sulphide, it is so inert that it does not darken lead white when they are mixed and as a result they have often been mixed for flesh tints.

Technical Examination Techniques/ Instrumental Analysis Techniques

Particles are anisotropic and appear to turn darker with pleochroism. Particles exhibit birefringence and some crystals exhibit characteristic undulose extinction. With the red compensator in the microscope they appear colours other than red and their polarisation colours are bright orange to red/brown depending upon their manufacture. Semi-transparent under infra-red, yellow-brown in false colour and purple-blue under UV light. When heated it sublimates at about 580°C and at higher temperatures it burns with a bluish flame. Insoluble in alkalis.