

Rembrandt: The Late Works

Science Teachers Word Bank

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Atomic number (Z)

The atomic number of a chemical element is the number of protons found in the nucleus of the atom. Lead, with an atomic number of 82, is regarded as a heavy metal and is present in pigments such as lead white.

Catalyst

A catalyst increases the rate of a chemical reaction, without itself being consumed in the reaction. Certain metal compounds can act as a catalyst in the 'drying' (polymerisation) of oils and may have been added to the paint deliberately for this purpose. Some pigments can also act as catalysts in the polymerisation of oil and are therefore known as 'good driers'.

Conservation

The main activities of conservators are cleaning, restoration, research, contributing to scholarly and exhibition catalogues, and ensuring that pictures lent and borrowed by the Gallery are in a sound state.

Cross-Section

A cross-section can be made from a tiny paint fragment or sample, which has been removed from a painting. The fragment will usually contain several paint layers and will be embedded in a block of polyester resin, then ground and polished to reveal its edge. This cross-section can then be examined under an optical microscope, which generally has a magnification range of 60 to 1000 times. By examining the paint fragment in this way, the layer structure of the sample can be observed. This information can be used to better understand how the painting was constructed. Many of the pigments seen in a cross-section can be identified using an optical microscope. More detailed information can be obtained by analysing it using a scanning electron microscope (SEM) with an energy-dispersive X-ray (EDX) detector.

Gas Chromatography – Mass Spectrometry (GC-MS)

Gas chromatography – mass spectrometry is a technique for the separation and detection of chemical components from complex mixtures. It is suited to the analysis of small quantities of material and is therefore ideal for providing detailed chemical information on the organic materials found in paint samples. It is particularly valuable for the identification of natural products such as oils and resins, where specific molecular indicators can distinguish between different species and can also be used to distinguish the different drying oils in paint samples, such as linseed and walnut oil.

Energy Dispersive X-Ray (EDX) analysis

This technique is a method of elemental analysis and is often carried out in the scanning electron microscope (SEM). A single paint layer in a cross-section, or an individual pigment particle of very small size, can be analysed for its constituent elements.

Fourier transform infrared (FTIR) Spectroscopy

Infrared spectroscopy is usually employed to identify the organic materials present in paint samples, such as the paint binder or varnish, although some pigments can also be identified using this technique. The molecules present in a sample absorb infrared radiation at specific wavelengths, producing a characteristic 'fingerprint' for each class of material. This technique uses a beam of infrared radiation containing wavelengths in the mid-infrared region (2,500 nanometres to 15,400 nanometres) and is different from infrared reflectography.

Impasto

Impasto is a style of painting where the paint is put onto a surface thickly and with visible brushstrokes and texture.

Infrared image (Infrared reflectography)

Near-infrared radiation (with a wavelength of between approximately 750 nanometres – 2500 nanometres) is often able to penetrate paint layers which are opaque to the human eye. The radiation passes through the paint until it reaches something that absorbs it, such as carbon black, or until it is reflected back to the camera. An image is formed by the different absorption and scattering properties of the paint at a given area of the painting. Infrared reflectography is most commonly used to see underdrawing – the design that the artist draws, usually in black, before beginning to paint.

Lead white (basic lead carbonate)

Lead white, or basic lead carbonate, is an opaque white pigment. It was the main white pigment used by artists until the 19th century and was produced artificially by exposing metallic lead to acetic acid in a carbon dioxide-rich environment. The pigment also acts as a catalyst in the 'drying' of oil paint.

Octahedral geometry

Transition metal complexes with an octahedral geometry have six ligands symmetrically arranged around the central metal ion. The colour of many transition metal complexes is related to the size of the band gap in the d-orbitals when they are split into two sets. The molecular geometry will alter the size of this band gap and will affect the colour of the complex.

Paint Binder (or Paint Medium)

In paintings, a binder (or medium) is the material that holds the coloured pigments together to form paint. In paintings at the National Gallery this is often a drying oil, but may also be egg yolk or animal glue.

Photo-oxidation

Photo-oxidation reactions require oxygen (or ozone) and light and therefore often take place close to the surface of a painting, such as in a varnish layer. The generation of oxygenated species can often lead to reactions which result in this layer becoming discoloured and brittle. The incorporation of oxygen into the resin molecules of a surface varnish will increase their polarity and will alter the solubility of the layer.

Pigment

Pigments are the colouring component of paint and can be made from a wide range of materials. These include minerals, natural and synthetic dyestuffs, and other manmade compounds. A pigment is a powder and is not soluble in the paint binder.

Polarity

Polarity refers to a separation of electric charge leading to a molecule or its chemical groups having an electric dipole. Molecular polarity is dependent on the difference in electronegativity between atoms in a compound and the asymmetry of the compound's structure. Polarity underlies a number of physical properties including surface tension, solubility, and melting- and boiling-points.

Polymerisation

Polymerisation is a chemical reaction where monomer molecules join together to form polymer chains or three-dimensional networks. The 'drying' of oil is a complex process, but involves the double bonds of the unsaturated fatty acids in the triglyceride molecules (the monomer units) reacting with oxygen in the air. These triglyceride molecules can then link together, forming a three-dimension network. In paint, where an oil binder has been mixed with pigments, these cross-linking reactions can sometimes be catalysed by certain pigments. This might affect the speed and type of polymerisation reactions which take place and therefore the physical and chemical characteristics of the paint film that is produced.

Sample

A tiny amount of paint is sometimes taken from the painting using a scalpel. The paint scraping or fragment is usually removed from the very edge of the painting or from next to an existing area of damage. It is so small that it can be difficult to see with the naked eye and must be examined using a microscope. If the sample is to be used to study the layer structure of the painting, it may be made into a cross-section. To identify the paint binder, the sample is prepared in a different way and analysed using Gas Chromatography – Mass Spectrometry (GC-MS) or Fourier transform infrared (FTIR) Spectroscopy.

Saturated and unsaturated fatty acids

A fatty acid is a carboxylic acid with a long, aliphatic chain. This chain is either saturated (it has no double bonds) or unsaturated (it contains double bonds). In oil paint, fatty acids are obtained from triglyceride molecules. The most common fatty acid found in linseed oil is linolenic acid, which has 18 carbon atoms and three double bonds.

Scanning Electron Microscopy (SEM)

The scanning electron microscope (SEM) is an instrument capable of magnifying objects up to 100,000 times – far greater than is possible with an optical microscope. There is no colour in SEM images because they are not produced using visible light. The SEM uses a focused beam of electrons to scan the surface of a sample under examination, generating several types of signal that can each be collected by a different type of detector. The SEM is often used together with Energy Dispersive X-Ray analysis.

Smalt

Smalt is a blue glass, ground into a powder. It was used as a pigment from the 16th to the 18th centuries. The blue colour comes from cobalt ions in the glass linked to oxygen ions in a tetrahedral geometry.

Soap

A soap is a metal salt of a fatty acid. In paint, the fatty acids derive from the triglyceride molecules of the oil and can react with the potassium ions leached from smalt to form soaps.

Solvent

A solvent is a substance that dissolves a soluble material (or solute). For example, varnish is insoluble in water but might dissolve in propanone or acetone. The solubility of a substance depends on many factors, but a solute will dissolve in a solvent that has a similar polarity ('like-dissolves-like').

Support

The support is the term used to describe the material on to which the artist has painted. It is usually a canvas or wooden panel, but other supports include copper or stone.

Tetrahedral geometry

Transition metal complexes with a tetrahedral geometry have the metal ion located at the centre and four ligands located at the corners of a tetrahedron. The colour of many transition metal complexes is related to the size of the band gap in the d-orbitals when they are split into two sets. The molecular geometry will alter the size of this band gap and will affect the colour of the complex.

Triglyceride molecules

Triglyceride molecules are esters of glycerol (a trihydric alcohol) with a range of different long chain fatty acids. Fats and oils are defined as mixtures of 'mixed triglycerides' that is each triglyceride molecule can contain different long chain fatty acids. A 'drying' oil has a high proportion of triglyceride molecules containing unsaturated fatty acids.

Varnish

A varnish is a clear, usually colourless coating, applied to bring out the colours of paintings more intensely (improve the saturation) and to protect the surface. Many different types of varnish exist, but traditional varnishes used by artists and conservators are made from natural resins, obtained from certain types of trees. These resins are dissolved in a solvent, which then evaporates leaving a clear film on the surface of the painting.

Viscosity

Viscosity is a measure of a fluid's resistance to deformation by stress and corresponds to a liquid's thickness. In general, the more pigment there is relative to binder, the thicker the paint and the more viscous it will be. Sometimes the drying oils themselves were thickened. A viscous paint with specific characteristics could then be produced using these thickened oils.

X-ray image (X-radiography)

X-rays can pass through most solid objects, but the greater the density of a material, the more it is able to impede X-rays. Some pigments contain metal ions that have a high atomic number (Z) and can be considered to have a high density. These pigments impede X-rays better than pigments containing chemical elements with low atomic numbers, so any areas of paint containing a large amount of such pigments will appear white in an X-ray image. X-radiography is useful for revealing the structure of a painting and any changes that may have occurred at different stages in its development.