

# **Appendix II.**

## PLM Investigations

**Polarized light microscope (PLM) observed particle characteristics:**

(from Gribble and Hall, 1992; Eastaugh, Walsh et al., 2004; Petraco and Kubic, 2004)

**Colour:** Starting point for identification; shade and intensity also assisted in differentiation, observed in PPL.

**Size:** Usually indicates origin – natural vs synthetic. Although exceptions exist, natural pigments are generally larger than synthetics. Size determined by examining the width of the particle, and are classified as coarse ( $>10\mu\text{m}$ ), large (10 – 3), medium (3 – 1), fine (1 – 0.3) and very fine ( $< 0.3$ ).

**Shape and edges:** The shape, like the size is also an indication of the origin of the pigment as synthetic pigments tend to have a rather rounded shape, with rounded edges. Crystals are more angular.

Also: Highly organised structure – crystalline

Randomly arranged atoms – amorphous

Light travels through crystal at same speed throughout (cubic) – isotropic

Different speed and refractive indices – anisotropic

*Amorphous substances are also isotropic*

**Surface:** Or surface texture, may be smooth or rough. A rough surface may be irregular, exhibit some form of fracture, cleavage planes, pits and so forth.

**Pleochroism:** Is the variation in colour of a single particle as a function of the crystallographic direction, seen by rotating the microscope stage. When a sample shows a two colour change it is said to be *dichroic*, when three or more colour changes are exhibited it is *pleochroic*.

**Refractive index:** The measure of light-bending power of particles as light passes through them (light passing from a less dense medium to a more dense medium). The higher the refractive index of the pigment, and the lower that of the vehicle, the greater the light reflection, resulting colour and hiding power. Refractive index (RI) is determined by the *Becke line*, which is a bright line that moves towards the material (pigment/meltmount  $n=1.552$ ) with the higher RI when the distance between the stage and the objective is increased (lowering stage). Therefore, if the RI of the pigment is less than that of the meltmount resin, as the stage is lowered the Becke line will move towards the medium.

**Birefringence:** Observed under XPL, and only works with anisotropic crystals. It refers to the difference in RI dependent on the path in which plane-polarised light travels through the sample. If anisotropic crystals are present they are usually seen at varying degrees of brightness and will blink or twinkle as the stage is rotated.

**Interference colours:** The varying colours observed under XPL.

**Extinction:** Number of times crystals appear dark or 'disappear' as the stage is rotated through  $360^\circ$ , usually at 4 points.