The inventor of Laser Particle Size Technology

Particle Size and Shape Analysis in

PAINT, INK and PIGMENT INDUSTRY

Generalities

A pigment is a natural or synthetic organic or inorganic substance capable of absorbing part of the light spectrum and re-emitting part of this light, which corresponds to the colour perceived by the eye (figure 1).
Pigments are used in a wide range of products such as inks and paints and in industries as varied as textiles, food processing and cosmetics.

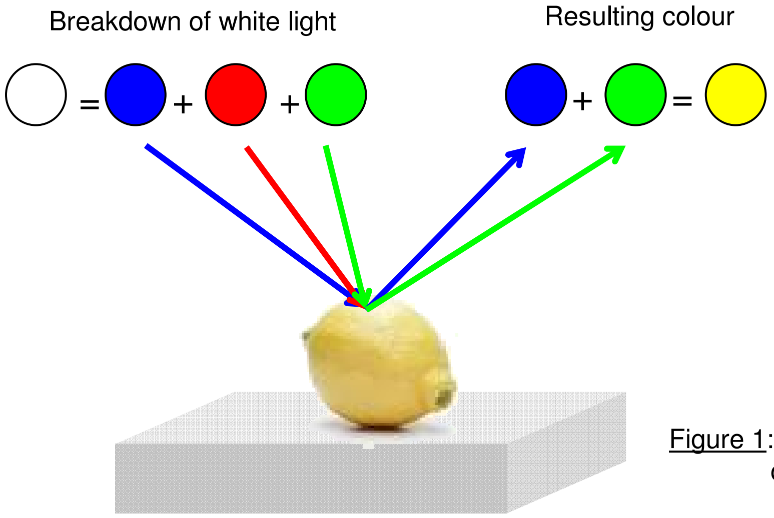


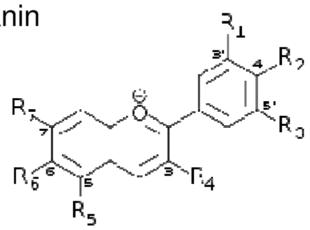
Figure 1: Absorption of light on a coloured object

Pigments can be either organic or inorganic, such as for example :

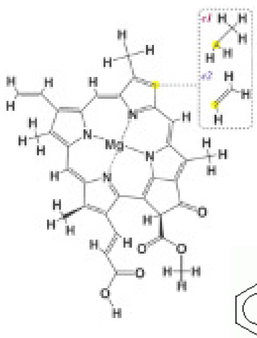
-Anthocyanin,
-Carotene,
-Chlorophyll,
-Indigo.

-Titanium oxyde (TiO_2),
-Calcium carbonate ($CaCO_3$),
-Kaolin (clays, $Al_4Si_2O_5(OH)_4$),
-Ferruginous clays.

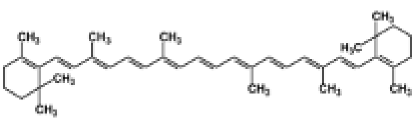
Anthocyanin



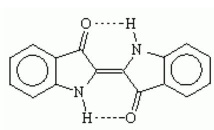
Chlorophyll



Carotene



Indigo



Why analyse particle size and shape ?

Particle size analysis

Effect of particle size on the optical properties

The particle size of pigments can affect the final appearance of the coated surface. For instance, a paint can be gloss, matt or satin, depending on the particle size. This effect is linked to phenomena of diffusion, reflection and refraction of light.

Small particles produce uniform and glossier coatings, where the angle of incident light is close to the angle of reflected light. Rigid polymers and polyethylene modify the properties of the films. When the thickness of the film is too high, the quality of transparent and coloured coatings is affected.

The finest particles reduce the imperfections of the film, whereas the chemical activity increases, such as for example automobile paints.

Figure 2: Gloss finish of an automobile bodywork

The ability of a given pigment to absorb light (tinctorial power) increases when the diameter of the particles is reduced and consequently by increasing the specific surface until the size at which the particles become transparent to incident light is attained.

For example, in the case of titanium oxide, TiO_2, the optimal size required is close to 1 µm.

Effect of particle size on the final performance of the coating

The chalking effect can be defined as the layer of dust that comes off a support when a hand is passed over a painted surface (figure 3).
This effect is a sign that the coating is ageing. Small particles increase this undesirable effect, although they enable good weathering resistance to be obtained.

The forces of interactions between particles directly influence the degree of hardness of the coating and thus its longevity.

Figure 3: Illustration of the chalking effect

The ease of application of a pigment or a paint is determined by the particle size distribution of the colouring elements.

The size of the particles directly determines the tinctorial strength or the depth of colour.

In addition, it can also be an important physical parameter in avoiding the obstruction of nozzles in the case of ink jet printing systems.

Effect of particle size on rheological properties and stability

Viscosity is increased by the presence of finer particles, which makes it possible to limit sedimentation and flocculation. These two phenomena can in particular modify the intensity of the colour of a formulation in a significant manner.

Rheological characteristics such as flow, viscosity, adhesion or thixotropic behaviour are affected by the particle size distribution (figure 4).

In order to limit phenomena of flocculation and agglomeration, it is possible to add surfactants. The physical and chemical mechanisms brought into play consist in limiting inter-particle interactions by steric or electrostatic effect.

This has the effect of limiting sedimentation and aggregation.

Figure 4: Viscosity measurement

[2] Rheology modification in mixed shape colloidal dispersions. Part I: Pure components Soft Matter, Volume 3, p. 1145–1162, (2007)

[3] Rheology modification in mixed shape colloidal dispersions. Part II: Mixtures Soft Matter Volume 4, p. 337–348, (2008)

[4] The influence of pigment particle shape on the in-plane tensile strenth properties of kaolin-based coating layers Tappi Journal Volume 5, N°12 (2006)

Morphological analysis

The morphology of particles plays a role in the thixotropic behaviour of fluids. Thixotropy is the property of some fluids to show a time-dependent change in viscosity.
For example, the intrinsic viscosity [η] of particles with the same volume is directly related to their aspect ratio (figure 5) [2-3].

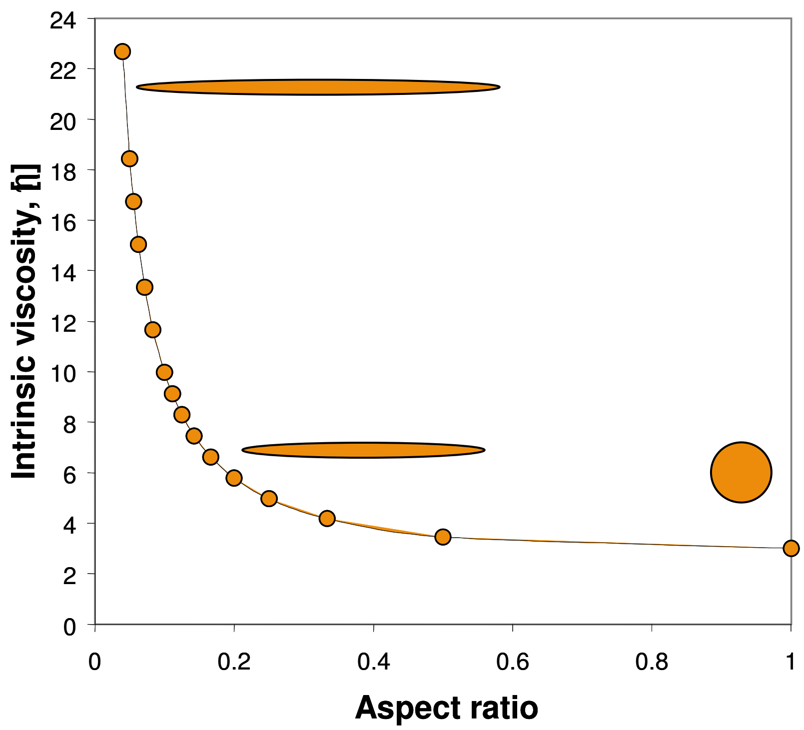


Figure 5 : Relation between intrinsic viscosity and aspect ratio

Kaolin pigments with similar particle size have in-plane tensile strength and stiffness of the coating layer increases as the shape factor of the clay particle increases. Conversely, elongation to break decreases. These observations are interpreted in terms of the microstructure of the coating layers.

How to analyse ?

Particle size range
Particle size distribution generally between 0.1 and 50 µm.
The D_{50} is generally situated between 1 and 10µm.

Liquide mode
Carried liquid : Water
Dispersing agent : Igepal
Ultrasounds : 60s during dispersion
Mathematical model : Fraunhofer

Dry mode
Vibration frequency : 45 - 55 Hz
Cyclical ratio amplitude : 45 - 55 %
Air pressure : 100 - 250 bars

Particle size analysis in liquid mode

Carried liquid : Water
Dispersing agent : Igepal
Ultrasons : None

Characteristic diameters of the particle size distribution shown in figure 6:

- D_{10} = 1.60 µm
- D_{50} = 4.63 µm
- D_{90} = 10.87 µm

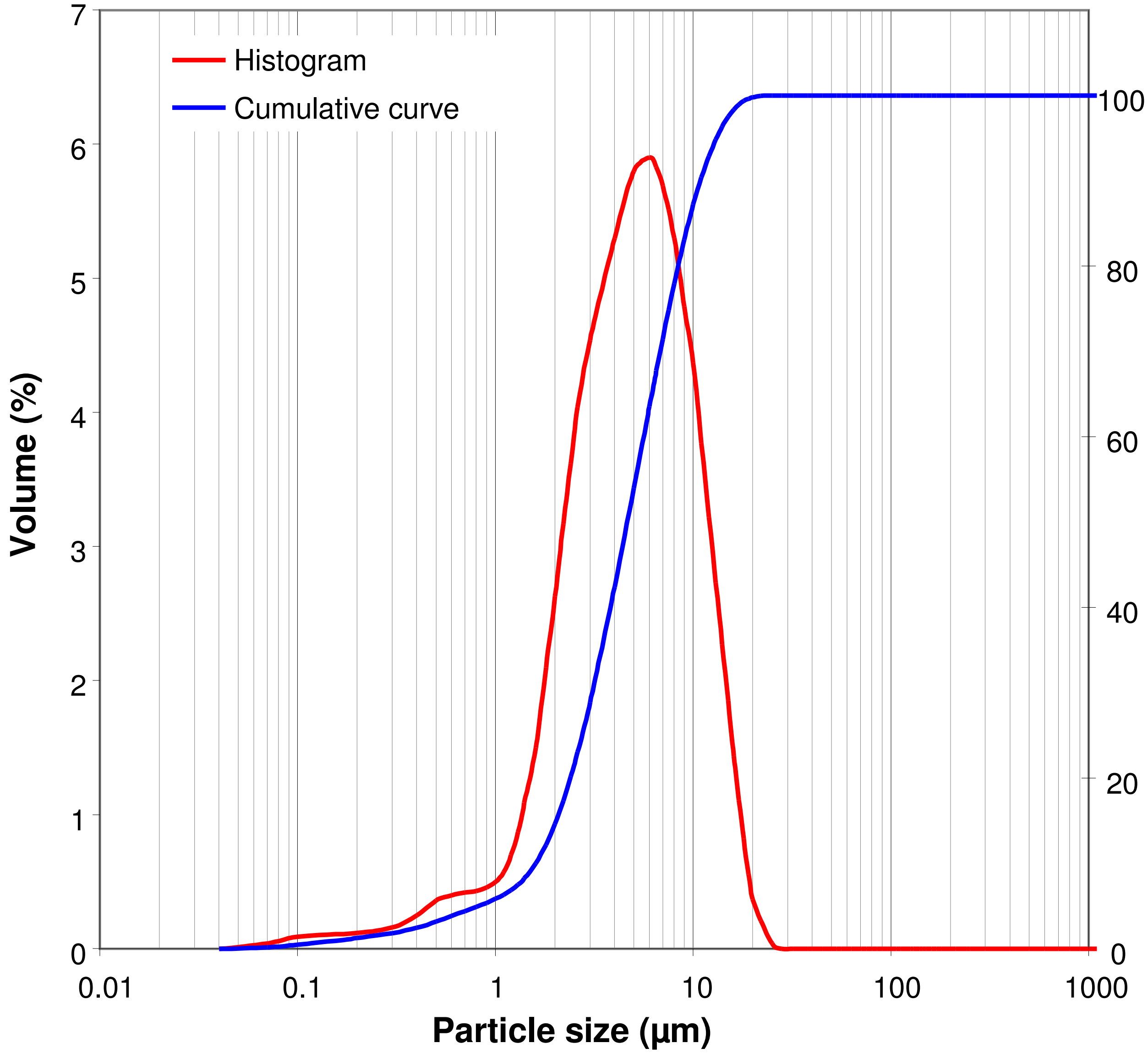


Figure 6: Particle size distribution obtained in liquid mode

Particle size analysis in dry mode

Frequency = 50 Hz
Cyclical amplitude ratio = 50 %
Air pressure : 200 mbars

Special diameters of the particle size distribution in figure 7 :

- D_{10} = 5.76 µm
- D_{50} = 10.49 µm
- D_{90} = 18.91 µm

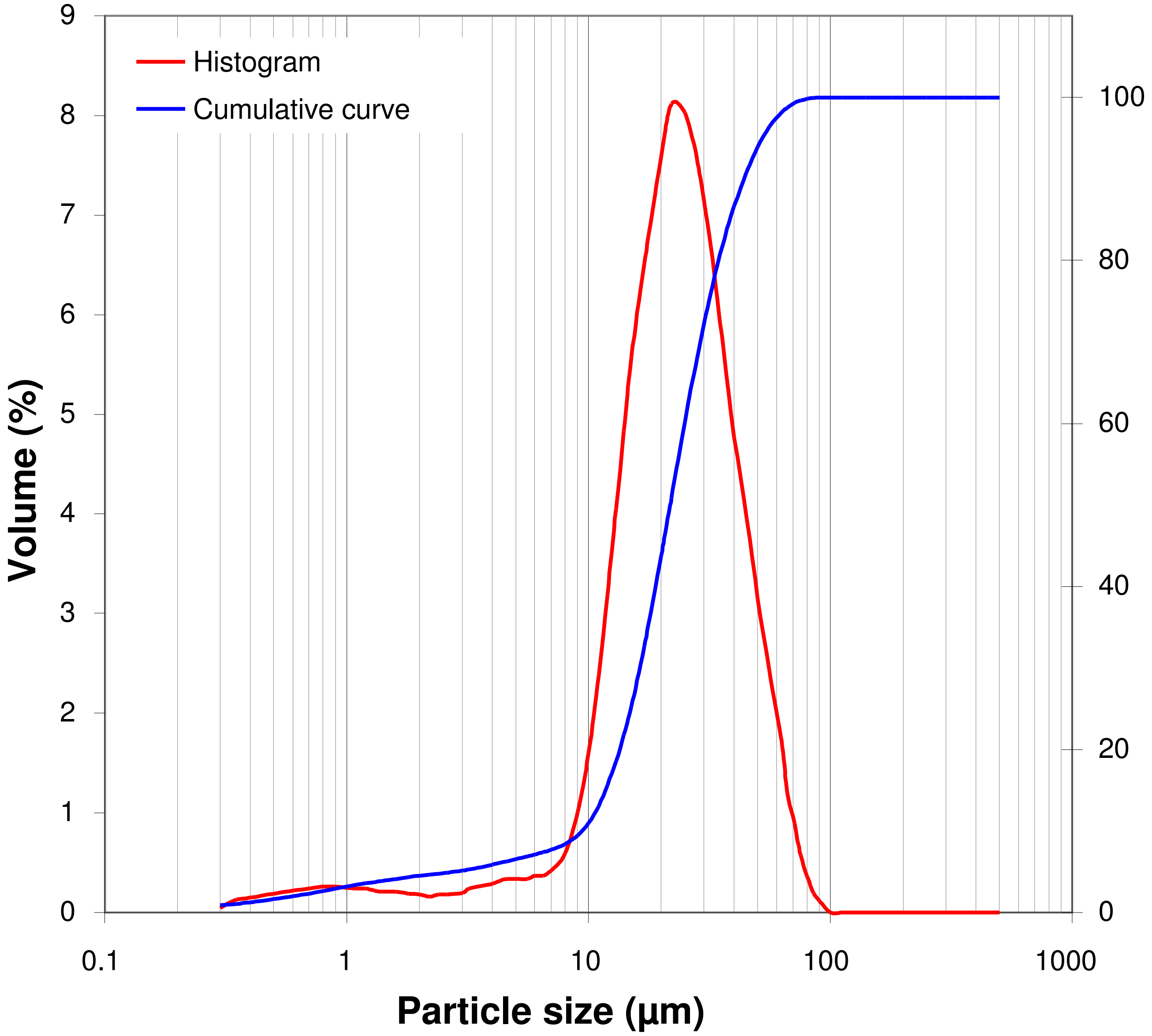


Figure 7: Particle size distribution obtained in dry mode

Shape parameters adapted for morphological analysis

An example of a characteristic image is shown in figure 8. This image was obtained by optical microscopy with x40 magnification.

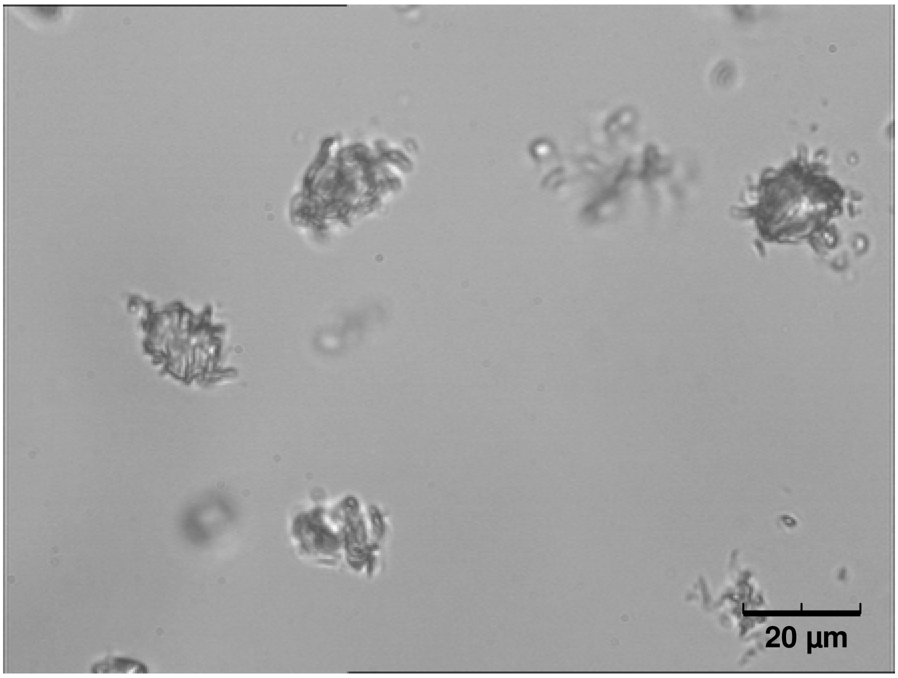


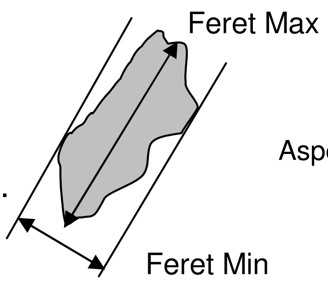
Figure 8: Characteristic image of a material used in paint industry obtained by optical microscopy

The morphological parameters that can be used for this application are:

Aspect ratio

Ratio between Feret Min and Max diameters.

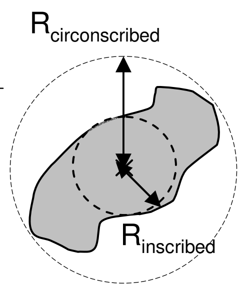
In the case presented, Aspect Ratio = 0.92.
This parameter enables the shape anisotropy to be quantified.



$$\text{Aspect Ratio} = \frac{\text{Feret Min}}{\text{Feret Max}}$$

Sphericity

$$\text{Sphericity} = \frac{R_{inscribed}}{R_{circonscribed}}$$



Ratio of the radiuses of the inscribed and circumscribed circles.

In the case presented, Sphericity = 0.88.
This parameter enables the deviation from circularity to be quantified.