



Particle Size Analysis and X-ray Refractometer

(* Arasakumar E¹, Navaneetha Krishnan², Vasanth V¹, Nilav Ranjan Bora¹ and Gajjala Nitish¹)

¹Department of Sericulture, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam - 641301, Tamil Nadu, India.

²Department of Silviculture and NRM, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam - 641301, Tamil Nadu, India.

*Corresponding Author's email: arasu20595@gmail.com

Particle size analysis is used to characterize the size distribution of particles in a given sample. Particle size analysis can be applied to solid materials, suspensions, emulsions and even aerosols. There are many different methods employed to measure particle size. Some particle sizing methods can be used for a wide range of samples, but some can only be used for specific applications. It is quite important to select the most suitable method for different samples as different methods can produce quite different results for the same material.

Who uses particle size analysis?

Particle size analysis is a very important test and is used for quality control in many different industries. In just about every industry where milling or grinding is used, particle size is a critical factor in determining the efficiency of manufacturing processes and performance of the final product. Some industries and product types where particle sizing is used includes:

- Pharmaceuticals
- Building materials
- Paints and coatings
- Food and beverages
- Aerosols
- Chemical industry
- Agriculture
- Mining
- Forestry

Chemical Industry: There are a large number of methods for the determination of particle size, and it is important to state at the outset, that these different methods are not expected to give identical results: the size of a particle depends on the method used for its measurement, and it is important to choose that method for its determination which is relevant to its use.

Mining: The size of materials being processed in an operation is very important. Having oversize material being conveyed will cause damage to equipment and slow down production. Particle-size analysis also helps the effectiveness of SAG mills when crushing material.

Agriculture: The gradation of soils affects water and nutrient holding and drainage capabilities. For sand-based soils, particle size can be the dominant characteristic affecting soil performances and hence crop. Particle-size analysis in the agriculture industry is paramount because unwanted materials will contaminate products if they are not detected. By having an automated particle size analyzer, companies can closely monitor their processes.

Forestry: Wood particles used to make various types of products rely on particle-size analysis to maintain high quality standards. By doing so, companies reduce waste and become more productive.

Aggregate: Having properly sized particles allow aggregate companies to create long-lasting roads and other products.

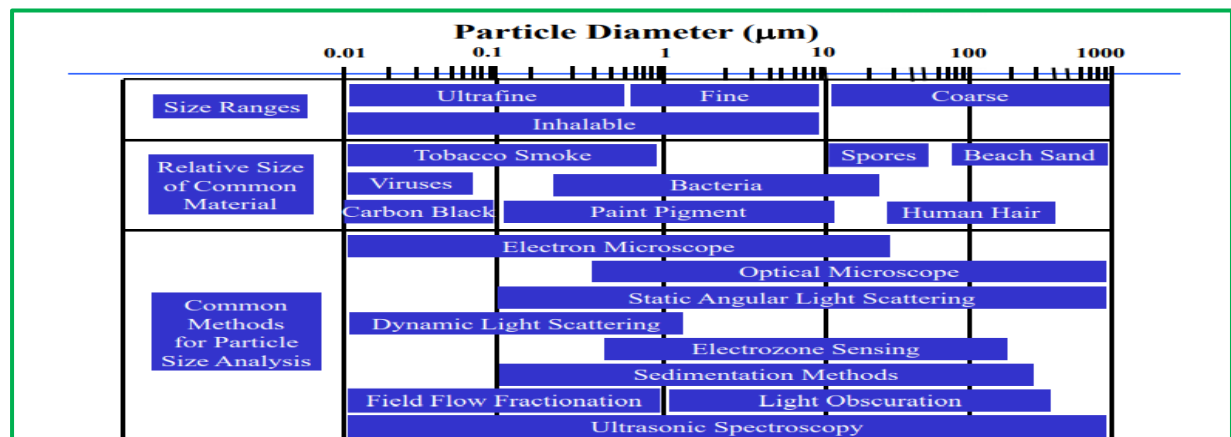
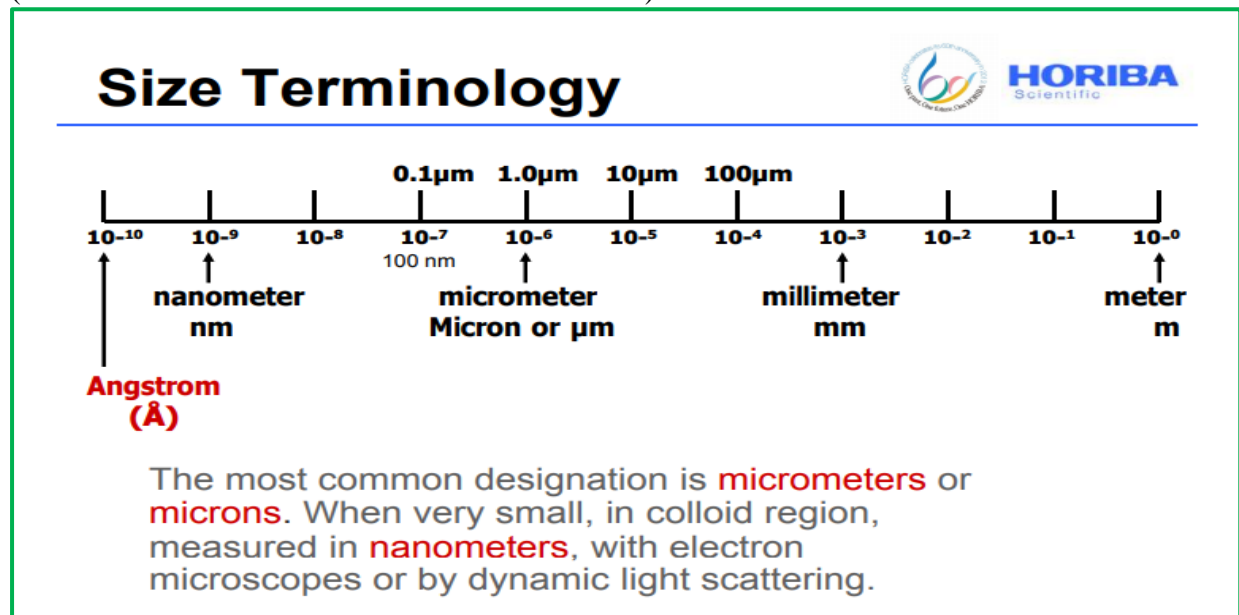
Biology: Particle size analyzers are used also in biology to measure protein aggregation.

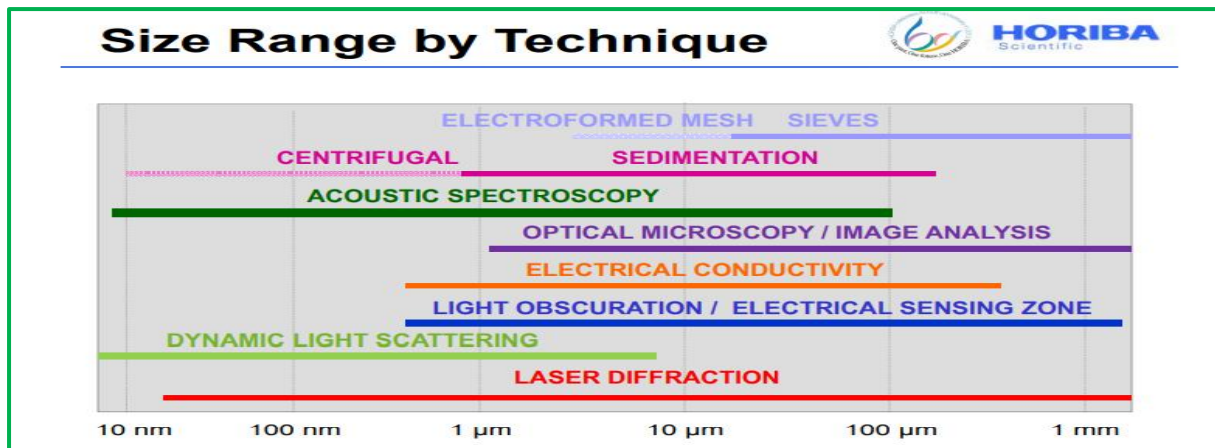
Equivalent sphere theory

One basic problem in particle size analysis is characterizing particles using just one number. Most particle sizing techniques aim report particle size distributions on a two-dimensional graph (i.e. particle size on the x-axis and quantity of material on the y-axis).

However, the difficulty with this is that there is only one shape that can be described by a single unique number, and that is the sphere. Only a sphere measures the same across every dimension. If we say we have a 100-micron sphere, this describes it exactly. We cannot say the same for a cube, where the 100-micron may describe the length of one edge, or even a diagonal transect.

For this reason, all particle sizing techniques measure a one-dimensional property of a particle and relate this to the size of an “equivalent sphere”. One example is to measure the surface area of a particle and then report the size of sphere which has the same surface area. Probably the most common method is to measure the “volume” of each particle in a sample and report the size of a sphere which has the same volume as the particles being measured (this is what is done in Laser Diffraction methods).



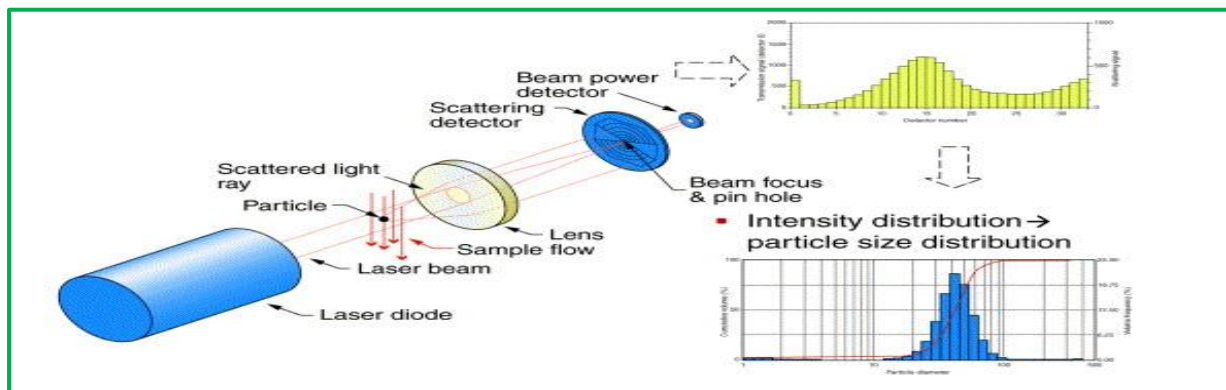


Particle sizing by laser diffraction

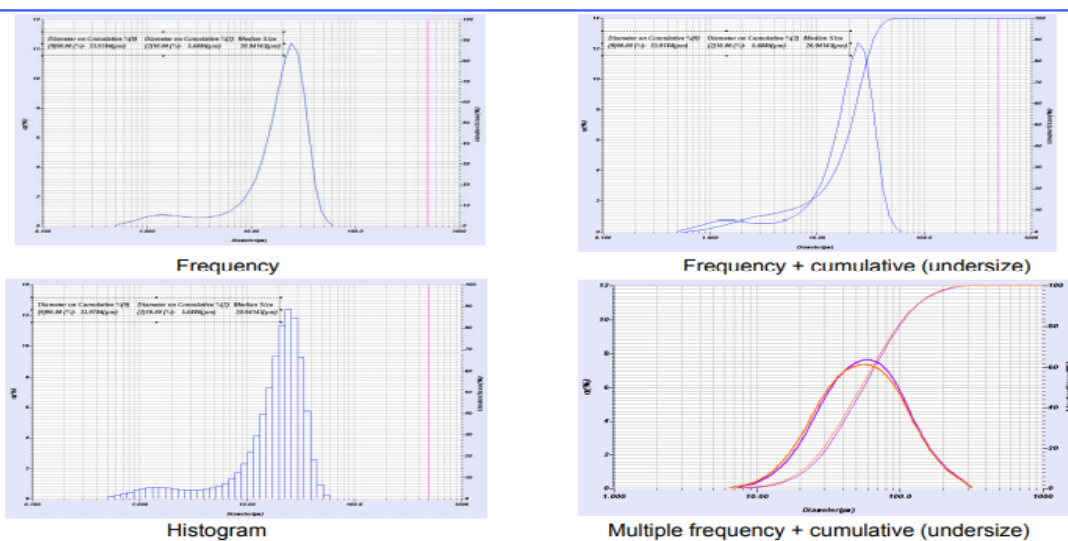
Laser diffraction has become one of the most commonly used particle sizing methods, especially for particles in the range of 0.5 to 1000 microns.

It works on the principle that when a beam of light (a laser) is scattered by a group of particles, the angle of light scattering is inversely proportional to particle size (ie. the smaller the particle size, the larger the angle of light scattering).

Laser diffraction has become very popular because it can be applied to many different sample types, including dry powders, suspensions, emulsions and even aerosols. It is also a very fast, reliable and reproducible technique and can measure over a very wide size range.



Your Analyzer's Displays



Other methods

- There are many other methods for analysing particle size, other than laser diffraction.
- **Sieving** is one of the oldest particle sizing methods and is still widely used for relatively large particles (ie. > 1mm).
- When measuring very small particles (ie. < 0.5 μ m), **Dynamic light scattering** is by far the easiest methods to use. And if you need to measure morphological properties of particles, (ie. shape as well as size), then image analysis methods are the only way to gain the extra information.

X-ray refractometer: It works on the principles of elastic scattering and uses monochromatic X-rays to analyze a sample. X-rays are initially generated from an X-ray source (often a cathode tube) before being filtered through a monochromator to produce X-rays of a single wavelength frequency. These are known as monochromatic X-rays. The X-rays are then concentrated and fired at the sample, where they are refracted by the atoms and detected by the detector.

Use of x-rays for structural analysis: The extensive use of X-rays for the analysis of atomic structural arrangements is based on the fact that waves undergo a phenomenon called diffraction when interacting with systems (diffracting centers) which are spaced at distances of the same order of magnitude as the wavelength of the particular radiation considered. X-ray diffraction in crystalline solids takes place because the atomic spacings are in the 10–10³ m range, as are the wavelengths of X-rays.

Diffraction and bragg's law: The extensive use of X-rays for the analysis of atomic structural arrangements is based on the fact that waves undergo a phenomenon called diffraction when interacting with systems (diffracting centers) which are spaced at distances of the same order of magnitude as the wavelength of the particular radiation considered. X-ray diffraction in crystalline solids takes place because the atomic spacings are in the 10–10³ m range, as are the wavelengths of X-rays.

USES

- Phase Composition of a Sample – Quantitative Phase Analysis: determine the relative amounts of phases in a mixture by referencing the relative peak intensities
- Unit cell lattice parameters and Bravais lattice symmetry – Index peak positions – Lattice parameters can vary as a function of, and therefore give you information about, alloying, doping, solid solutions, strains, etc.
- Residual Strain (macrostrain)
- Crystal Structure – By Rietveld refinement of the entire diffraction pattern
- Epitaxy/Texture/Orientation
- Crystallite Size and Microstrain – Indicated by peak broadening – Other defects (stacking faults, etc.) can be measured by analysis of peak shapes and peak width.

Diagram

