Application Note 158

The Effect of Particle Shape on Particle Size Measurement

Particle size analysis has a broad range of applications encompassing virtually all industries. Numerous automated techniques exist for measuring particle size distribution and virtually all report particle size in units of equivalent spherical diameter. This is necessary because of the ambiguity of describing the diameter of an irregularly shaped particle, and of constraints inherent in the instrument detection system.

Different measurement techniques that report in equivalent spherical diameter produce somewhat different particle size distributions when particles are nonspherical. Understanding what each particle size technique actually measures, how it performs the measurement, and how it transforms the quantity measured into equivalent spherical diameters are crucial when selecting the most appropriate particle sizing technique for your sample or application. To demonstrate this, we analyzed samples of glass beads, garnet, and wollastonite (because of their shape differences). The analytical techniques employed are static laser light scattering, electrical sensing zone (Coulter Principle), X-ray sedimentation, and dynamic image analysis. The effect particle shape has on the reported particle size is discussed for each of these materials and techniques.

Laser Light Scattering

The basic assumption of laser light scattering is that spherical particles of different sizes scatter light in patterns of intensity versus the scattering angle that are specific to the diameter of the particle. The scattering patterns are additive when particles of different sizes are involved. The particle sizes reported by this technique are the *diameters of spheres in an assemblage of spherical particles that produce the same, or most nearly the same, scattering pattern* as that detected by the instrument.

Electrical Sensing Zone

The electrical sensing zone technique measures the difference in electrical signal strength end-to-end across an orifice filled only with electrolyte to the signal strength when a non-conducting particle is present in the electrolyte as it passes through the orifice. From this measurement, the volume of electrolyte displaced by a particle, and therefore the volume of the particle, is determined. The particle size reported by this technique is essentially *the diameter of a sphere that displaces the same volume of electrolyte as the detected particle*.

Sedimentation

Particle size by sedimentation is determined by measurement of the terminal velocities of particles settling in a fluid medium. The particle size reported by this technique is *the diameter of a sphere of the same material that settles at the same terminal velocity as the test particle in the same fluid and under the influence of the same force.*

Dynamic Image Analysis

Dynamic image analysis acquires images of particles as they pass through the detection zone. Linear dimensions of the cross-sectional shape of each image are analyzed using a variety of shape parameters. The particle size reported by this technique is in terms of *these linear dimensions.*

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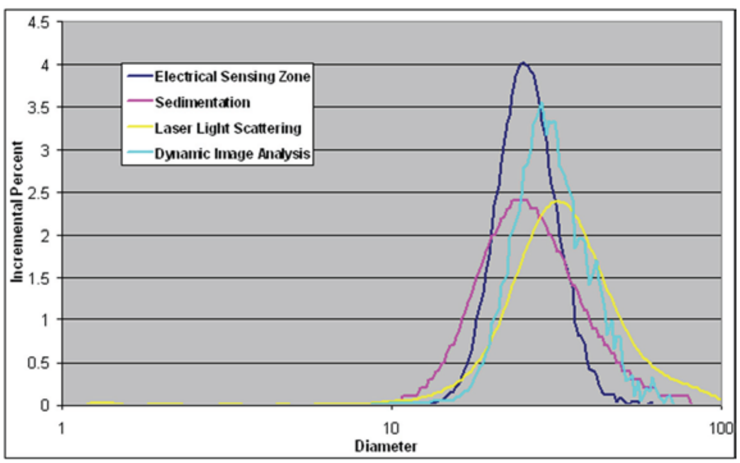
Analytical Technique Properties

The table below lists the analytical techniques, the fundamental property determined, and the Micromeritics analyzer that employs each technique and which were used to generate data used in this study.

Analytical Technique	Basic Measurement	Particle Variables Affecting Measurement	Micromeritics Analyzer
Laser light scattering	Light intensity versus scattering angle	Refractive index, shape, orientation	Saturn® DigiSizer II
Electrical sensing zone	Change in electrical signal across a conducting orifice	Porosity, conductivity	Elzone® II
Sedimentation	Settling velocity	Density, shape	SediGraph® III
Dynamic image analysis	Linear dimensions of projected cross-section of particle	Particle orientation	Particle Insight

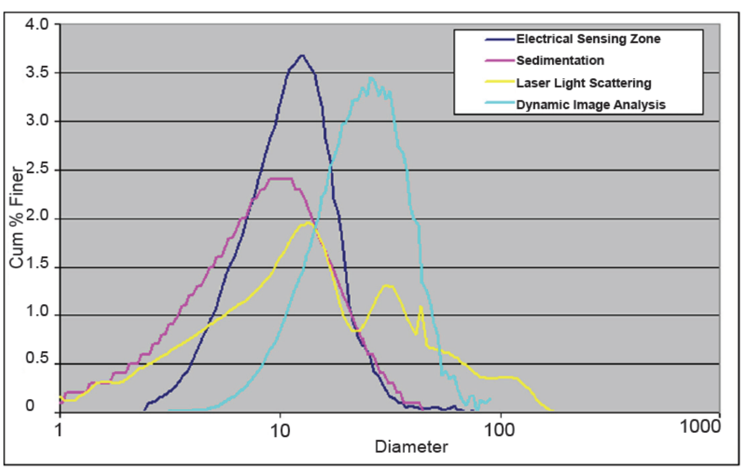
Testing Results

Garnet



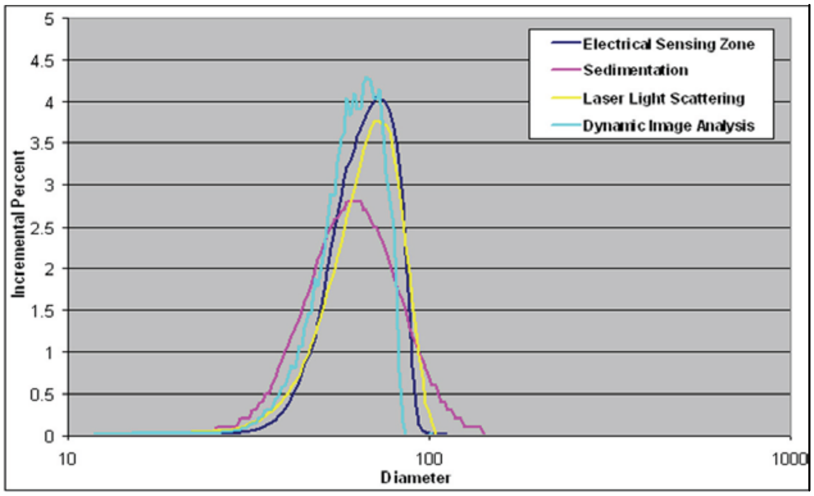
Garnet crystals approximate cubic shapes. Since the diagonal of a cube is approximately 30% longer than a sphere of the same volume, larger particle size is reported by methods that take orientation into account (laser light scattering and dynamic image analysis).

Wollastonite



Wollastonite particles are rod-shaped. Since the apparent dimensions of a rod-shaped particle can vary drastically depending on its orientation, the detection methods that were affected by particle orientation (laser light scattering and dynamic image analysis) exhibited larger particle size measurements and broader peaks.

Glass Spheres



Glass spheres, as expected, produced the most consistent results for the different techniques. Since the particles are spherical, their orientation has no effect on their measurement. Microscopy of the sample indicated that the glass spheres contained air bubbles in variable sizes, reducing somewhat the density of some of the spheres. Because of this, the SediGraph detects some of the particles as being undersized and, therefore, widens the distribution and shifts it to a slightly finer size.