**Techniques in particle sizing and analysis.**

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| **Technique** | **Measurement/Characteristics** | **Applications** | **Characteristics** | **Limitations** | ***Standards*** |
| Scanning force microscopy (SFM). Also under SFM Scanning Tunnelling Microscopy (STM) and Near-Field Scanning Optical Microscopy (NSOM) | Typical range: 10µm to 1000µm  Techniques for surface characterization of properties like topography, elasticity, friction, adhesion, and electrical/magnetic fields. | Powders | This is a technique for imaging surfaces by mechanically scanning their surface contours,  in which the deflection of a sharp tip sensing the surface forces, mounted on a compliant cantilever, is  monitored.  Ensemble technique. The multi-mode scanning probe microscope is the high-resolution metrology and imaging tool performs a complete range of AFM. | Traditionally, an AFM cannot scan images as fast as a SEM. The relatively slow rate of scanning during AFM imaging often leads to thermal drift in the imagemaking the AFM less suited for measuring accurate distances between topographical features on the image. | *BS ISO 13095:2014. Surface Chemical Analysis. Atomic force microscopy. Procedure for in situ characterization of AFM probe shank profile used for nanostructure measurement*  *BS ISO 11039: 2012 Surface chemical analysis -- Scanning-probe microscopy -- Measurement of*  *drift rate*  *ASTM E 2859-11 Standard guide for size measurement of nanoparticles using atomic force*  *microscopy* |
| Acoustic Spectroscopy | Typical range: 10µm to 1000µm  Techniques for concentration, size and size distribution. | Powders and Aerosols | This is a technique which is sound propagation through a nanomaterial in a  suspension or an emulsion. | Applicable only to | *BS ISO 20998-1 Measurement and characterisation of particles by acoustic methods-Part 1: Concepts and procedures in ultrasonic attenuation spectroscopy*  *BS ISO 20998-2 Measurement and characterisation of particles by acoustic methods-Part 2: Guidelines for linear theory* |
| Dynamic Light Scattering (DLS) | Typical range: 50nm to 1µm.  Techniques for size and size distribution. | Powders | Ensemble technique. Also commonly used in chemical and pharmaceutical industries. Relies on Brownian motion of particles in a liquid medium to determine particle size. | Morphological information limited to aspect ratio. No surface information. Imaging of individual particles impossible. Sample must be dispersed in liquid, which can alter particle characteristics. Range is comparable to AFM, but fails to span the gap to measure in the 1µm to 10µm range. | *BS ISO 22412:2008. Particle size analysis. Dynamic light scattering (DLS)*  *ASTM E2490 Standard Guide for Measurement of Particle Size Distribution of Nanomaterials in*  *Suspension by Photon Correlation Spectroscopy (PCS)* |
| Differential mobility analysing DMA + CNC | Typical range: 50nm to 1µm.  Techniques for concentration, size and size distribution. | Aerosols | Ensemble technique. DMA creates monodisperse stream of particles; relies on mass-based charge to isolate particles within a specified size range. CNC grows small particles to a size large enough to detect with other techniques, such as light scattering. Typical range: >10nm | No morphological information. No surface information. Imaging of individual particles impossible. CNC alters particles before they are measured. | *A combined DMA-CNC test system for commercial laser particle counters, I am not aware of a standard being developed.* |
| Scanning Electron microscopy (SEM) | Typical range: 50nm to 1cm.  Techniques for shape, Agglomeration, chemical composition size and size distribution. | Powders and Aerosols | Single particle technique. Compositional information can be obtained with EDS. | Sample preparation can be complex Generally must be performed at vacuum. Costly equipment. | *ASTM E2809 - 13. Standard Guide for Using Scanning Electron Microscopy/X-Ray Spectrometry in Forensic Paint Examinations* |
| Transmission Electron microscope (TEM) | Typical range: 5nm to 500µm. | Powders and Aerosols | Single particle technique. Compositional and crystallographic information can also be obtained. | Since e-beam is transmitted through sample, image is 2D projection of sample. Sample preparation can be very complex. Must be performed under vacuum. Costly equipment. | *A number of standards mainly pertinent to air quality.*  *ASTM D6281 - 09. Standard Test Method for Airborne Asbestos Concentration in Ambient and Indoor Atmospheres as Determined by Transmission Electron Microscopy Direct Transfer (TEM)* |