Analysis of Multimodal Particle Size Distribution of a Mixture of Four Different Sized Silica Standards

Outline

Silica particle size standards with National Institute of Standards and Technology (NIST) traceable certified mean diameters are suitable for a wide variety of particle measurement applications. The standards are designed for applications requiring monodispersed inorganic spheres. Silica spheres provide more contrast than polymer particles as they are opaque in an optical cell. They also have a higher density than polystyrene particles, making them ideal for sedimentation measurements. Fig. 1 is a photograph of silica particles from Thermo Fisher Scientific Inc. (TFS). This time, four types of monodispersed colloidal silica Sigma-Aldrich™ (SA) were mixed to evaluate the resolution and quantitative capability of the centrifugal sedimentation method.

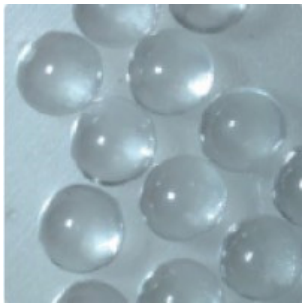

Fig. 1 Photograph of silica particles that is used with permission from Thermo Fisher Scientific Inc.

Method

Apparatus: HORIBA Partica CENTRIFUGE
Measurement mode: Line-start
Sample volume: 10 µL
Samples: SA_No.44054: Silica/De-ionized (DI) water, Nominal size: 5 µm, Mean: 4.83 µm, Density: 1,800-2,000 kg/m³
: SA_No.56798: Silica/DI water, Nominal size: 1 µm, Mean: 1.04 µm, Density: 1,800-2,000 kg/m³
: SA_No.56796: Silica/DI water, Nominal size: 0.5 µm, Mean: 0.489 µm, Density: 1,800-2,000 kg/m³
: SA_No.56799: Silica/DI water, Nominal size: 0.15 µm, Mean: 0.145 µm, Density: 1,800-2,000 kg/m³
Calibration sample: TFS_No.8100: Silica/DI water Nominal size: 1.0 µm
Particle: Silica (Solid concentration: 5%, Refractive index: 1.450, Average density of mixed silica particles: 1,900 kg/m³)
Medium: 8-24% sucrose density gradient solution (Average refractive index: 1.352, Average density: 1,048 kg/m³)
Particle size distribution (PSD) base: Volume based
Calculation setting: QC mode

Results

A volume of 10 µL was collected with a micropipette for a 1-µm silica/water dispersion and injected to the cell cap of a cell filled with density gradient liquid for calibration. Thereafter, one drop (almost equal volume) each of four silica/water dispersions having different particle sizes were collected and mixed well. 10 µL was collected from this mixture with a micropipette, injected to the cell cap, and sample measurement was performed by Partica CENTRIFUGE. As shown in Fig. 2, the volume-based PSD with four peaks was obtained after the measurement.

The mode diameter of the peaks are 0.144 µm, 0.493 µm, 1.026 µm, and 4.306 µm.

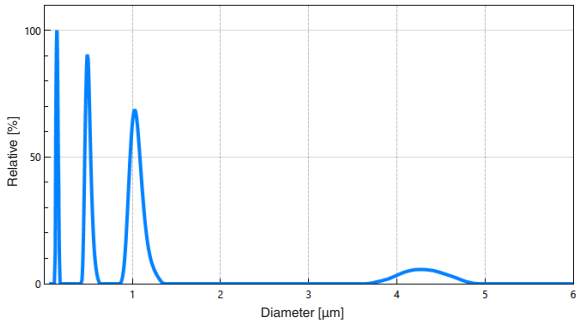

Fig. 2 Volume-based PSD

Conclusion

When silica/water dispersions of different sizes were mixed in almost equal volume and measured by the centrifugal sedimentation method, a PSD having four peaks was observed, resulted from differences in sedimentation rate due to particle size. Also, when calculated as a volume-based PSD, it could be confirmed that each particle size standard was in equal volume, since the area ratio of each peak corresponded to the volume ratio of each particle size standard. In other words, the phenomenon that the concentration and absorbance of the particles are usually not proportional was corrected in the quantitation process even though there were particles smaller or equal to the wavelength of the light source. In this way, the centrifugal sedimentation method is able to provide a quantitative measurement with high resolution and accuracy.

*Sigma-Aldrich is a trademark of Merck KGaA, Darmstadt, Germany or its affiliates for their life science business.