SHIMADZU

Application News

Nano Particle Size Analyzer: SALD-7101 No. 8

Reason for Adopting UV Light Semiconductor Laser
(Measurement Lower Limit and High Sensitivity Measurement Background)

When the particles to be measured are placed in a medium having a refractive index different than that of the particles, and which are then irradiated with laser light (collimated beam), scattered light is generated from the particles. In the “dynamic light scattering method (DLS)”, the time-course changes in scattered light intensity are utilized to measure particle size; however, in the “laser diffraction method” adopted in the SALD-7101, the special changes in light intensity (light intensity distribution pattern) dependent on the scattering angle is utilized to measure the particle diameter (particle size distribution).

Figure 1 shows the relationship between particle diameter and the light intensity distribution pattern when an ultraviolet laser beam with a wavelength of 375 nm is used.

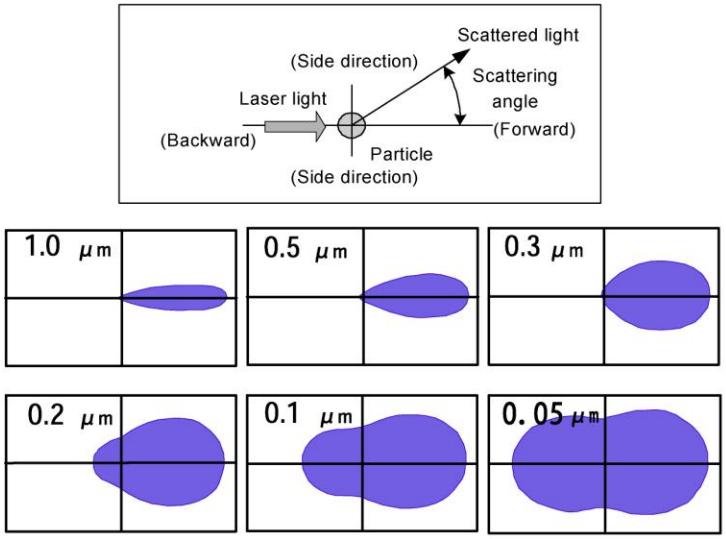

Figure 1: Relationship between Particle Diameter and Scattered Light Intensity Distribution Pattern

For example, the scattered light from a 1 μm particle is concentrated in the forward direction. As the particle diameter becomes larger than 1 μm, the scattered light is concentrated in a narrower scattering angle range.

Conversely, as the particle diameter becomes smaller, the scattered light is generated over a wider angle, and when the particle diameter decreases to 0.2 μm and smaller, the scattered light in the side and backward directions becomes stronger. Moreover, when it becomes 0.05 μm (50 nm), the scattered light intensities barely change in the backward and forward directions.

Because the scattered light intensity distribution pattern changes with respect to particle diameter in this manner, conversely, the particle diameter can be identified from the scattered light intensity distribution pattern.

In an actual measurement instrument, the particle size distribution is obtained using the relationship between particle diameter and the light intensity distribution pattern calculated theoretically based on the Mie scattering theory. Once the particle size decreases to 0.01 μm (10 nm) or smaller, even further decreases in particle diameter produce no changes in the scattered light intensity distribution pattern. Moreover, the scattered light intensity decreases rapidly in proportion to the sixth power of the particle diameter. This is the reason for the existence of the measurement lower limit.

Strictly speaking, both the light intensity distribution pattern and scattered light intensity depend not on particle diameter d, but on the particle diameter parameter α in the equation:

$$\alpha = \pi d/\lambda$$

Here, π is the circular constant, and λ is the incident light wavelength.

If we assume that wavelength λ is halved, even if the particle diameter d is halved, the particle diameter parameter α remains unchanged, so the light intensity distribution pattern and scattered light intensity also remain unchanged. Therefore, if wavelength λ is shortened, it becomes possible to measure even smaller particles. This is the reason why the SALD-7101 adopts the 375 nm wavelength ultraviolet semiconductor laser as the light source.

For example, if 375 nm is used as the wavelength as compared to 680 nm, even when measuring nanoparticles of the same size, 36 times the scattered light intensity can be obtained, the reason why high-sensitivity measurement from just a few ppm can be realized with the SALD-7101.

The particle size distribution of ribosome shown in Figure 2 is the result of measurement at an extremely low particle concentration of less than 3 ppm (weight concentration).

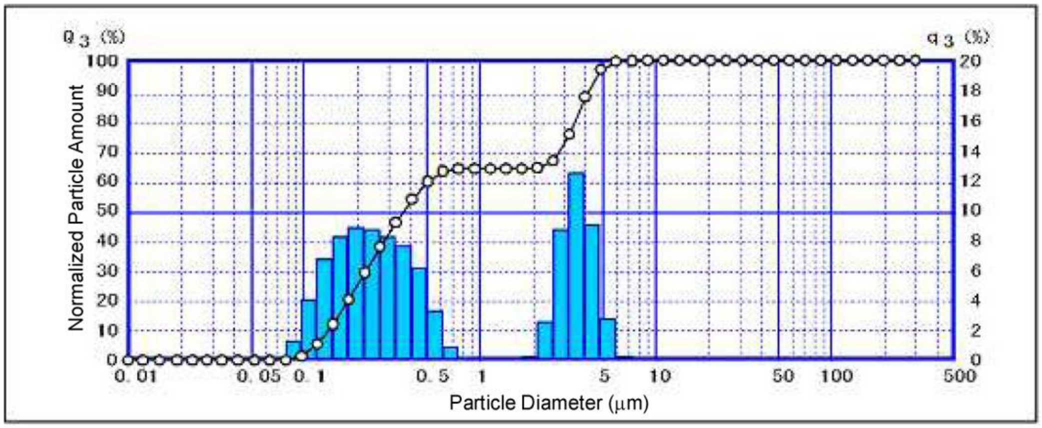

Figure 2: Measurement Results of Ribosome

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