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Nanoflowsizer

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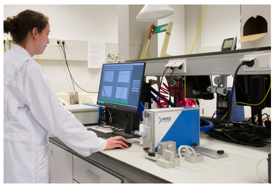

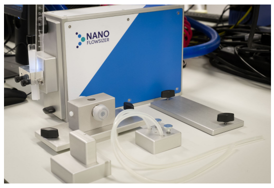

Brand

InProcess-LSP

Type

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Description

The NanoFlowSizer is a recent developed equipment to measure particle size distributions in turbid systems. The particle size distribution is for a broad range of applications an important quality parameters and usually estimated using light scattering techniques with well-known equipment like the NanoSizer and MasterSizer. The new method, based on optical coherence tomography, is especially suitable for fast and reliable measurement of particle size distributions of concentrated turbid systems, either inline, online, or offline as well as in flow. The NanoFlowSizer is suited for a broad range of applications and contributes to finding answers to relevant research questions.

Technical Details

Particle size distribution is for various materials an important quality parameter. This includes the droplet size distribution in emulsions, bubble size distribution in aerated systems as well as molecular, particle, and aggregate size distribution in suspensions. Applications are found in many disciplines like food, pharma and (bio)chemistry. A well-known technique for particle size measurement is light scattering, where the intensity of light of a specific frequency is measured that is scattered by the particles at different angles and/or times. Static light scattering (SLS) is often used for determination of particle sizes in the micrometer to millimeter range. Typical instrumentation for measuring particle size distribution using SLS is the Mastersizer (Malvern). For particles in the nanometer to micrometer range, dynamic light scattering (DLS) is used. Typical equipment for particle size determination using DLS is the Zeta or Nano-sizer (Malvern). In general, for a correct interpretation of the angle dependence of the scattered light intensity (SLS) and autocorrelation function of the scattered light intensity at one or more scattering angles (DLS) it is important that the scattered light is due to the scattering of only one scattering event (single light scattering). For turbid systems this is often a problem because due to the large concentration of scattering particles, light entering the detector is mainly the result of multiple scattering. To minimize the multiple scattering, samples are often diluted. This, however, is mostly unwanted because particle size distribution can change due to dilution and change of environment and equilibrium between the particles, like e.g. is the case for protein solutions. A way around could be the use of diffusing wave spectroscopy (DWS) which corresponds to dynamic light scattering in the multiple-scattering regime. However, for DWS interpretation of the scattering autocorrelation function is tedious and complicated, which makes the estimation of particle size distribution in concentrated turbid systems problematic.
Recently a new light scattering technique has been developed based on optical coherence tomography (OCT) using a broad-band light source in combination with a Michelson interferometer, that is especially suitable for fast and reliable measurement of particle size distributions of concentrated turbid systems. The technology can be described as Spatially Resolved Dynamic Light Scattering (SR-DLS) and can be used either inline, online, or offline. Furthermore, particles size distributions can be determined when the system is in motion (flow) in contrast to existing particle size measurement techniques. The instrumentation is called the NanoFlowSizer.
SCIENTIFIC ASCPECTS, APPLICABILITY AND ADVANTAGESThe science behind the NanoFlowSizer is the application of low coherence interferometry that allows characterization of the scattered light at high frequency as function of (penetration) depth in the sample. This yields multiple correlation functions, each characterizing intensity fluctuations at a particular depth or path length. The spatially resolved character allows distinction between single and multiple scattered light, because shorter path lengths will contain typically single scattered light. This allows direct measurement of relatively high concentrated nano-suspensions (typically 50-100x more concentrated compared to standard DLS).

Scheme of Spatially Resolved Dynamic Light Scattering principle
Besides the ability to measure turbid systems at high concentrations, with this technique one can account for flow effects on the data. This because the spatially resolved intensity correlation data contain besides the information on diffusion speed also information on the flow profile. Both can be distinguished using advanced algorithms, which allows extraction of size information during flow. For adequate flow correction, laminar flow conditions are most suitable - turbulent flows may lead to misinterpretation of the data. The maximum allowed flow-speed depends on particle size and optical properties of the suspension, diameter of piping and data acquisition frequency. The faster the diffusive dynamics due to Brownian motion (smaller particles, lower viscosity), the higher the flow speeds that may be applied.

Monitoring stirred polystyrene suspension
The particle size data like Z-average (mean particle size) is typically obtained within 5-10 seconds. Particle size distribution can be obtained within 1 to 2 minutes, depending on complexity of the distribution and required precision. Continuous measurement of the particle size properties allows continuous monitoring of the intended process.

The NanoFlowSizer can be used inline as well as off-line. The ability to measure directly through various glass interfaces (such as vials/flasks) in combination with flow correction during e.g. stirring and a short analysis time provides significant advantages over the conventional DLS technology. The NanoFlowSizer can measure particle sizes in a similar range as conventional DLS although particles smaller than about 10 nm are currently outside the operational range of the NanoFlowSizer.

Online and offline adapters for the NanoFlowSizer
We have tested the equipment using a 7 wt% casein micelle concentrate to which glucone delta lactone (GDL) was added that causes a slow decrease in pH, which induces micellar aggregation. Measurements were performed using a small vial. Results using the NanoFlowSizer clearly show aggregation of the micelles. Furthermore size distributions correspond well with those obtained using multi-angle dynamic light scattering, which needs much more effort.

Applications

The NanoFlowSizer is suited for a broad range of applications, like food and biobased as well as environmental and soil science. Within the environmental and soil sciences the technique will give valuable information on soil composition and quality that allows optimization of crop production and yield. Within the food area, the technology will deliver valuable information to relate ingredients, process and product quality and properties, like structure and shelf life, which is essential to develop innovative and sustainable products and processes.