Coupling of Sedimentation Field-Flow Fractionation (SdFFF) with Laser-induced Breakdown Detection (LIBD) as a Sensitive Colloid Separation and Sizing Method with high Resolution

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Colloids (sizes between 1 nm and 1 µm) are present in all aquatic systems [1]. They have a high specific surface to mass ratio and so a large sorption capacity. Colloid bound pollutants and/or colloidal pollutants can result in exceeding of thermodynamic solubility of the respective chemical compound. That is why colloids are of major importance for the transport of hazardous substances [2]. In addition, disease-causing microbial impurities (algae, bacteria, viruses, …) themselves can be called colloids and nano-particles as such are often unwanted particular contaminants reducing the product quality in many modern production processes (e.g. semiconductor industry). Therefore it is necessary to quantify the amount and the size of colloids present in aquatic systems and to assess their stability as well as their chemical composition.

Field-flow fractionation (FFF) is a method used to separate colloids and suspended particles. Separation takes place in a flat channel, through which a carrier flow transporting the colloids is passed. Due to the channel geometry, a laminar flow profile develops. In sedimentation FFF (SdFFF), channel rotation results in a centrifugal force acting on the sample perpendicular to the direction of the carrier flow. Due to their larger diffusion coefficient, the smaller particles diffuse into the region of the higher flow velocities of the laminar flow and are therefore eluted prior to the larger particles [3]. The potential of FFF techniques are limited by the particle detection methods available. Especially in the lower nm colloidal size range detection methods like laser light scattering (LLS) are not sensitive enough to register colloids in low concentrations.

Laser-induced breakdown detection (LIBD) is a sensitive analytical tool for the quantification of low concentrations of colloids with diameter in the lower colloidal size range. During the detection process plasmas are generated on single particles by a focused laser beam and the plasma light emissions produced are detected [4]. The evaluation of the number of plasma events per number of laser shots results in a breakdown probability, dependent on particle concentration and size. For the determination of colloid sizes the light emission of single plasmas are detected by use of a image processing system [5]. With known mean particle diameter and breakdown probability the particle concentration can be calculated [6]. The laser-induced breakdown effect and the principal of LIBD are described in detail in the literature [4-8].

The LIBD is up to 1,000,000 times more sensitive in comparison to light scattering (see "Sensitivity of the LIBD" on the poster). Therefore the direct, on-line coupling of our SdFFF with the mobile constructed LIBD is the future objective. Such SdFFF/LIBD instruments, or preferably all FFF/LIBD instrumentation will act as high resolution elution methods for separating and sizing a wide range of environmental and industrial samples. First measurements of FFF fractions with the LIBD machine off-line showed a drastically enhancement of the sensitivity especially for the very small colloidal particles in the size range below 0.1 µm. Considerable improvements in all nano-particle related research fields can be expected.

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