Laser-induced Breakdown Detection (LIBD) as a novel and highly sensitive method for nano-particle analysis

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Nano-Particles (colloids) are omnipresent in the environment, as well as in industry, biotechnology and pharmaceutical industry. Colloids are fine-dispersed particles with diameters from ca. 10^{-9} m up to 10^{-6} m [1.]. Due to their very small size, nano-particles/colloids feature a large surface in relation to their mass. This property is responsible for the high sorption capacity of numerous materials, and colloids are capable of stabilizing materials/pollutants beyond the thermodynamic solubility of their respective compounds in solution. On the other hand, nano-particles are often undesired and difficult to detect impurities that impair the product quality within many fields of state-of-the-art production engineering (e.g. semiconductor industry, pharmaceutical industry). Beyond that, colloids of biological nature (e.g. bacteria, viruses) can have a crucial influence on the quality of e.g. medicine products or on our worldwide most important nutrient: *drinking water*.

The quantification of aquatic colloids is quite a difficult task because they are often to be found in small concentrations and often show a colloid size distribution where small particles ($d < 10^{-7}$ m) dominate. Commercial light scattering techniques enable a direct, non-invasive quantification. Problem is that light is strewn not only by the colloids which are to examined selectively, but also by the solvent as well as gas bubbles and scratches on the wall of the sample cell and that the detection limits for small particles with diameters below 10^{-7} m are frequently not sufficient.

In recent years the Laser-induced Breakdown Detection (LIBD) was developed as a new method for the quantification of colloids [2., 3.]. The principle of the LIBD is based on the generation and counting of breakdown events on colloidal particles in liquids. Due to the difference of the breakdown threshold (laser pulse power density, which is necessary for the production of a plasma) between solid, liquid and gaseous matter (it is lowest for solids), plasmas can be generated selectively on particles in liquids [4.]. The laser pulse energy is reduced to a level so that in pure liquid no breakdown events are produced, but in presence of colloidal particles the breakdown threshold within the focal area is exceeded. The number of breakdown events per number of laser pulses is defined as breakdown probability and depends on particle concentration and size. For the determination of particle sizes, plasmas are recorded by means of an image processing system and the distribution of the plasma events along the laser beam axis is determined. The expansion of this distribution of plasma events depends directly on the particle size and is independent of the particle concentration. With knowledge of particle size and breakdown probability colloid concentration can be calculated [5].

The main advantage of LIBD in relation to light scattering techniques such as Photon Correlation Spectroscopy (PCS) is a higher sensitivity of several orders of magnitude, especially in the particle size range < 10^{-7} m (see fig. 1).

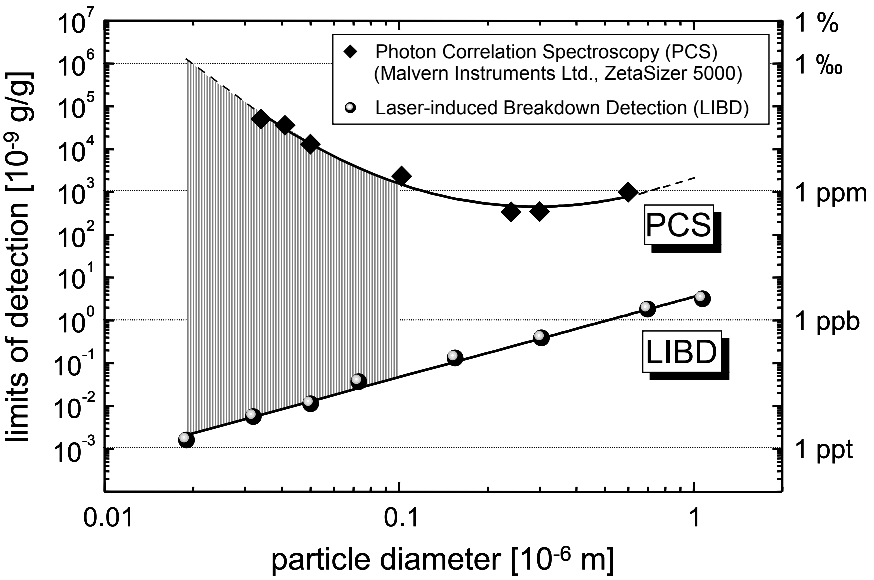

Fig. 1: Limits of detection from Photon Correlation Spectroscopy (PCS) and Laser-induced Breakdown Detection (LIBD).

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