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Characterization of Nanofluids by Dynamic Light Scattering

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Nanofluids containing nanometer-sized particles in liquids are relevant in many technological applications such as cooling agents in electronic components or lubricants in machinery. For process design and modeling, information on size, shape, and their distributions as well as on stability of the particles dispersed in liquids is needed. In this connection, dynamic light scattering (DLS) representing a non-invasive technique to study microscopic relaxation processes in fluids at macroscopic thermodynamic equilibrium can be used. While the study of particle size and its distribution by DLS can be performed in a routine way for diluted transparent nanofluids with spherical particles,[1] technically interesting nanofluids which are often not fully transparent and which have volume fractions of more than 0.1% imply challenges. The aim of the present study is to show the applicability of DLS for the characterization of particle size, morphology, and their distributions in semi- and non-transparent nanofluids.

As model systems, water-based nanofluids with metallic oxide nanoparticles of varying size, shape, and concentration were investigated. For the characterization of semi- or non-transparent samples with particle volume fractions up to 1%, scattered light was analyzed in backward direction at scattering angles larger than 90°. Here, the scattering volume was shifted close to the boundary of the samples to suppress effects caused by multiple scattering and laser heating.[2] To compensate the low scattering intensities, a heterodyne detection scheme is applied where much stronger reference light is superimposed to the scattered light. In polarized DLS where polarized scattered light is detected, the decay rate of fluctuations in the particle number density is related to the translational particle diffusion coefficient D_P of spherical and non-spherical particles. The D_P data provide not only access to particle size and its distribution, but give also information on the stability of nanofluids. Using depolarized DLS where the incident light is vertically polarized with respect to the scattering plane and horizontally polarized scattered light is registered, the translational and rotational diffusion of non-spherical particles such as rods can be dissociated. Here, the decay rate depends not only on D_P, but also on the rotational diffusion coefficient D_R.[3] The latter value is used to deduce the shape of non-spherical particles in the form of their aspect ratio.

References

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