Dynamic Light Scattering on Magnetite-Based Ferrofluids

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Goals

To investigate the magnetoviscous effect in ferrofluids two complementary techniques of Dynamic Light Scattering are used. These provide information on viscous properties and effective particle sizes without applying external mechanical forces.

Methods

With Dynamic Light Scattering (DLS) the temporal behavior of scattered light is analyzed; it has become a standard method for the determination of diffusion coefficients D of particles in highly diluted disperse systems [1]. Using the Stokes-Einstein relationship they can be transformed into hydrodynamic radii. By using backscattering geometries or fiber-optic detection (FOQELS) to suppress multiple scattering the method can be applied to systems with high particle concentrations of up to 50 % [1-3].

Capillary Wave Spectroscopy (CWS) optically probes thermally excited surface waves and allows to measure the change of viscous properties due to external magnetic fields without additional shear stress [4].

First Results

We have performed a series of DLS-experiments with a commercial iso-octane based ferrofluid (Buske, Berlin; M_{sat}= 47.5 kA/m; $\phi(Fe_3O_4) = 0.105$) under backscattering geometry, where the influence of the particle concentration and of an external magnetic field (up to H = 20 kA/m) on the apparent hydrodynamic radii r_H has been systematically investigated.

Without a magnetic field a monomodal size distribution is obtained with an r_H of about 9 nm in agreement with results from other techniques. In this case there is no evidence of larger aggregates.

Upon application of an external magnetic field ($H = 20 \pm 5$ kA/m) a second mode corresponding to a much larger particle structure appears.

Effects of structure formation under an applied magnetic field also become apparent in CWS-measurements [4]. The variation of the relative orientation between magnetic field and the scattering wave vector results in two different sets of dynamics of the scattered light from the liquid surface. These first CWS-experiments demonstrate the anisotropy of the viscous properties under the influence of an external magnetic field.

Acknowledgments

This work is supported by the DFG priority program 1104.

References

[1] R. Pecora, Dynamic Light Scattering, Plenum Press, New York, 1985.

[2] L. Lilge, D. Horn, Colloid Polym. Sci. 269, 704 (1991).

[3] H. Wiese, D. Horn, J. Chem. Phys. 94, 6429 (1991).

[4] D. Langevin, Light Scattering by Liquid Surfaces and Complementary Techniques, Marcel Dekker, New York, 1992.