Hydrodynamic properties of core-shell nanoparticles with tunable shape anisotropy

Ilya Martchenko, Hervé Dietsch, Christian Moitzi, and Peter Schurtenberger

University of Fribourg, Adolphe Merkle Institute and Fribourg Center for Nanomaterials, Route de l'Ancienne Papeterie, CP 209, 1723 Marly 1, Switzerland

Email: ilya.martchenko@unifr.ch

Colloidal particles have frequently been used as versatile model systems to investigate classical problems in condensed matter physics such as nucleation, crystallization or glass transition. Recently the emphasis has shifted to anisotropic particles or particles interacting via non-centrosymmetric interaction potentials. In order to investigate the influence of the aspect ratio on the structural and dynamic properties of colloidal suspensions, we have thus established a model system consisting of almost monodisperse hematite spindles covered by a layer of silica, which allows us to tune the particle aspect ratio between 5 and 2. In this context, we have systematically studied translational and rotational mobility of these core-shell particles using a combination of polarized (DLS) and depolarized (DDLS) dynamic light scattering with transmission electron microscopy (TEM).

The geometrical dimensions (length L and width d) were determined from TEM micrographs. Appropriately weighted average translational (D_T) and rotational (D_R) diffusion coefficients were calculated based on the TEM data using models for ellipsoids and spherocylinders. Experimental values for DT and DR were obtained from polarization-dependent (VH- and VV-geometry) dynamic light scattering over a large range of scattering angles (16^o to 148^o). The comparison between TEM-based theoretical predictions and experimental data clearly demonstrates that the particles in the investigated range of aspect ratios are well described by the models for smooth non-draining ellipsoids and spherocylinders. This finding is illustrated in Figure 1 for the translational diffusion coefficient D_T.

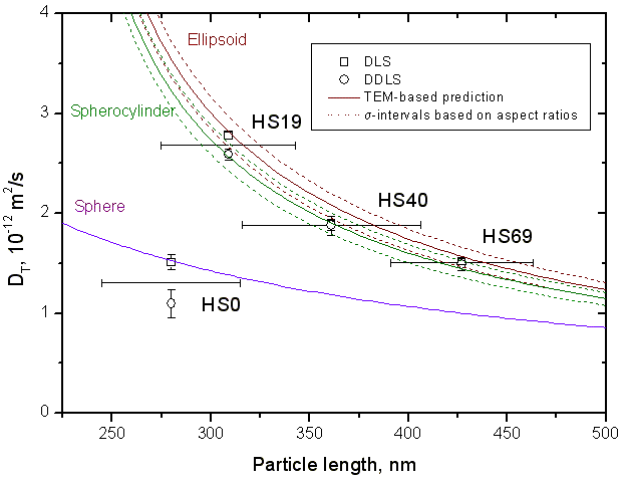

Figure 1: Comparison of measured and theoretical DT values as a function of particle length. The dotted curves correspond to deviations caused by the standard deviation σ for the aspect ratios. The horizontal bars indicate the length polydispersity of the particles.