Ordering of hydrophilic and hydrophobic nanoparticles in thin aqueous films

Yan Zeng[1], Sebastian Schön[1], Adrian Carl[1], Stefan Grandner[2], Sabine Klapp[2], Regine v. Klitzing[1]
[1]Stranski-Laboratorium, Institut für Chemie, TU Berlin, Germany
[2]Institut für Theoretische Physik, TU Berlin, Germany
klitzing@chem.tu-berlin.de

The hydrophobicity of nanoparticles decides about their ability to adsorb at the air/water interface or to stay rather in the aqueous solution. The first part of the talk addresses the ordering of hydrophilic Silica nanoparticles (26 nm in diameter) in thin aqueous films which present a model system for thin films of complex fluids. In the second part of the talk the same Silica nanoparticles are hydrophobized by short amphiphiles which allows stabilizing foams (Pickering foams). The common question of both parts is how the particles order under confinement in a thin film or at an air/water interface.

Hydrophilic Si-nanoparticles
Characteristic lengths of the structuring of silica nanoparticle suspensions confined between two flat silica surfaces are extracted from the oscillatory force profile of colloidal-probe atomic force microscopy (CP-AFM) measurements and compared with the bulk counterparts as obtained from structural peak of small angle X-ray scattering (SAXS) [1]. The oscillatory wavelength λ of silica nanoparticle suspensions scales with the particle number density as $\lambda=\rho^{-1/3}$, irrespective of particle size, surface charge of the particles [2] and ionic strength of the solution. CP-AFM measurements of silica nanoparticle suspensions on mica substrate, polyelectrolyte-coated rough surface(s) [3], and deformable air-liquid interface [4] are further applied to investigate the effect of confining surface properties on the corresponding structuring. CP-AFM measurements on modified and deformable confining surfaces show an increase in force amplitude with increasing surface potential and decreasing surface roughness and deformability. However, the corresponding wavelength and correlation length remain unaffected.

Hydrophobized Si-nanoparticles (Pickering foams)
Silica nanoparticles can become effective foam stabilizers when they are partially hydrophobized. Foams were prepared from dispersions of silica nanoparticles with different degrees of hydrophobic modification by a short chain amine. The samples show strong synergistic effects in terms of foamability and foam stability compared to solutions that contain the hydrophobic amine or unmodified silica particles only. The systems were characterized at various length scales from the nanometer to the centimeter scale. With increasing hydrophobicity, the nanoparticles form a colloidal network around the air bubbles, whereby the fractal dimension of the network shows a strong effect on foamability and structure of the macroscopic foam. For the latter studies we measured the lateral pressure at the air bubble leading to an isotherm similar to the one at a planar air/water interface on a Langmuir trough. Furthermore, a strong relation between foam stability and gelation of the particles in the bulk phase is observed.

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