Interfacial nanoparticle self-assembly: recent hard X-ray studies.

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The recent spectacular increase of scientific interest in nanoparticle (NP) self-assembly is motivated both by the wide spectrum of current and potential technological applications, and by the fact that NPs can be used as model systems for the investigation of fundamental physical phenomena. New characterization techniques are constantly devised and improved to better probe the structure and dynamics of these systems. Particularly challenging is the nano-structural characterization when the particles self-assemble at deeply buried solid/liquid or liquid/liquid interfaces.

The High-Energy Micro-Diffraction apparatus of the ID15 beamline of the ESRF was originally developed for the study of interfacial ordering phenomena in atomic and molecular systems. We have extended its domain of application into the nanoparticle/colloidal domain with studies of solvent-mediated NP self-assembly processes.

The core of the talk will deal with hard x-ray reflectivity (XR) studies of surfactant-induced adsorption of silica NPs at buried, flat water/hexane interfaces. A detailed physical modeling of the XR data allows extraction of the average Young-Dupre contact angle θ for the NPs confined to the liquid-liquid interface. The NP interfacial binding energy ΔE, as calculated from the obtained θ values, falls in the expected range. However, our results [1] suggest that the classical ΔE computation may partially lose its accuracy for few-nm-sized particles, at least in the relatively complex NP/surfactant systems investigated here.

If time allows, we will concisely present also recent in-situ grazing-incidence small-angle hard x-ray scattering studies of the evolving nano-structure during gold NP self-assembly at solid surfaces in conditions of controlled solvent evaporation and subsequent controlled nano-scale re-wetting.

[1] D. Calzolari, D. Pontoni, M. Deutsch, H. Reichert, and J. Daillant, in preparation, 2011.