



Studying complex nanoparticle adsorption at liquid interfaces

A Nelson^{1,3}, D Wang², K Koynov², N D Spencer³ and L Isa¹

¹Laboratory for Interfaces, Soft Matter and Assembly, Department of Materials, ETH Zürich, Switzerland, ²Max Planck Institute for Polymer Research, Germany, ³Laboratory for Surface Science and Technology, Department of Materials, ETH Zürich, Switzerland

Trapping at the interface, combined with lateral mobility and the presence of specific interactions, makes self-assembly of colloidal particles at liquid-liquid interfaces (SALI) a process with huge potential for the creation of controlled structures, including novel ultrathin membranes and capsules.

It has been demonstrated that superparamagnetic iron oxide nanoparticles (NPs) stabilized by low molecular weight poly(ethylene glycol) (PEG) shells [1,2], adsorb and form saturated monolayers at water/oil interfaces [3,4]. Understanding the basics of this process is fundamental in directing the assembly of these NPs for applications. In particular, measuring the viscoelastic properties of the interfacial assemblies *in situ* and on the micro-scale is of utmost importance [5].

The effect of different PEG shells on the interfacial adsorption behaviour of the particles has been characterised using pendant drop tensiometry (PDT) at different concentrations. Particles with longer linear PEG chains show the highest surface activity and the fastest adsorption kinetics. Master curves have been created for the different particle types, demonstrating the concentration dependence of adsorption speed.

To further investigate the behaviour of the nanoparticles at the decane-water interface, the monolayer mechanical properties have been characterised via the tracking of passive probe particles of very different sizes. Micron-sized tracer particles, observed using fluorescence optical microscopy, show diffusive behaviour at the interface upon adsorption of the NPs. Fluorescence correlation spectroscopy (FCS), using quantum dots as tracers [6], was used to investigate the interface on the same length scale as the NPs. Surprisingly, these tracers also showed purely diffusive behaviour, with a progressive slowing down ascribed to NP adsorption. Using FCS, it was possible to follow the build-up of the NP monolayer with time, and to obtain master curves for the diffusion coefficient as a function of a concentration-dependent effective time, similar to the PDT master curves.

- [1] Amstad Esther, Gillich Torben, Bilecka Idalia, Textor Marcus, Reimhult Erik. 2009. *Nano Letters* 9:4042–4048
- [2] Gillich Torben, Acikgöz Canet, Isa Lucio, Schlueter A Dieter, Spencer Nicholas D, Textor Marcus. 2013. *ACS Nano* 7:316–329
- [3] Isa Lucio, Amstad Esther, Textor Marcus, Reimhult Erik. 2010. *Chimia* 64:145–149
- [4] Isa Lucio, Amstad Esther, Schwenke Konrad, Del Gado Emanuela, Ilg Patrick, Kroeger Martin, Reimhult Erik. 2011. *Soft Matter* 7:7663–7675
- [5] Ortega Francisco, Ritacco Hernan, Rubio Ramon G. 2010. *Current Opinion in Colloid & Interface Science* 15:237–245
- [6] Wang Dapeng, Yordanov Stoyan, Paroor Harsha Mohan, Mukhopadhyay Ashis, Li Christopher Y, Butt Hans-Jürgen, Koynov Kaloian. 2011. *Small* 7:3502–3507