Diffusion of single nanoparticles at oil-water interfaces as revealed by fluorescence correlation spectroscopy

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A good understanding of the dynamics and self organization of nanometer-sized objects, e.g., molecules, macromolecules and nano-particles (NPs) at immiscible liquid-liquid interfaces is not only of fundamental interest for the soft mater physics and cell biology, but is also very important for a number of technological applications in material synthesis, pharmacy, microfluidics and nanotechnology. The diffusion is the most common transport process and often controls the self organization. That is why one particularly important question is how the adsorbed particles diffuse on the liquid-liquid interface. The range of experimental techniques that can be used to study NPs diffusion on liquid-liquid interfaces is also rather limited. The optical (fluorescence) microscopy combined with particle tracking that has proved very useful for addressing the micron size colloids dynamics at liquid-liquid interfaces cannot be easily applied to nanoparticles and even less to single molecules due to the limitations in both sensitivity and speed.

(a) the FCS observation volume is positioned on the oil-water interface; (b) the fluctuations in the fluorescent intensity caused by the diffusing quantum dots are recorded; (c) autocorrelation analysis of these fluctuations followed by an appropriate fit yields the interface diffusion coefficient;

Here, we show that the fluorescence correlation spectroscopy (FCS), a method based on measuring the fluctuations of the fluorescent light intensity caused by the fluorescent species diffusing through a small observation volume, typically the focus of a confocal microscope is very well suited for studies of NPs diffusion on liquid-liquid interfaces as it offers the possibility to monitor fast diffusing, nanometer size objects, at extremely low surface coverage. We used FCS to study the diffusion of fluorescent semiconductor nanoparticles (quantum dots) on planar oil-water interfaces. The effects of several important parameters, i.e. the particles size, their surface functionalization (hydrophobic/hydrophilic) and the oil phase viscosity were systematically explored. Most notably, a significant decrease of the NP diffusion coefficients as compared to the corresponding bulk values was observed, especially for the NPs located in the middle of the interfaces.