Measuring single nanoparticle wetting properties

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Nanoparticles (NPs) at fluid interfaces are central to a rapidly increasing range of nanotechnological applications, including drug delivery[1], functionalized NPs for uptake through biological membranes[2], emulsion stabilization[3] and the fabrication of nano-composite materials[4]. Investigations on the effect of solid particles at liquid interfaces date back to the work of Ramsden[5] and Pickering[6] who discovered that adsorbing small particles on the surface of the emulsion droplets greatly enhances their stability against coalescence. Since then, considerable experimental and theoretical efforts have been devoted to the study of micro- and nanoparticle adsorption, assembly and dynamics at fluid interfaces[7]. Despite this, understanding wetting at the single-nanoparticle level is an unresolved issue and is essential in designing NP-building blocks with controlled surface properties. We present here an approach based on freeze-fracture and cryo-scanning electron microscopy, which greatly surpasses the current state-of-the-art, and pushes the boundaries of true single-nanoparticle contact angle measurements to the 10-nm range, relevant for applications[8]. We demonstrate measurements on hydrophilic and hydrophobic, organic and inorganic NPs. This approach poses no constraints on the choice of liquid phases and thus is generally applicable to many systems of fundamental and applied interest.
Cryo-SEM images of different NPs at the liquid-liquid interface after freeze-fracture. The shadow cast by the particles upon metal deposition is visible in the high magnification images.