Researchers track nanoparticle dynamics in three dimensions

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(Phys.org) -- Researchers from the NIST Center for Nanoscale Science and Technology have used three-dimensional single-particle tracking to measure the dynamic behavior of individual nanoparticles adsorbed at the surface of micrometer-scale oil droplets in water.

The results revealed that the diffusion of the particles depends on their size, with smaller particles diffusing much more slowly than expected. A detailed understanding of how colloidal nanoparticles interact with interfaces is essential for designing them for specific applications in fields ranging from drug delivery to oil exploration and recovery. The researchers developed a feedback control system with real-time control electronics to actuate a piezoelectric stage, moving the sample in order to lock the moving nanoparticle in the observation volume of an optical microscope.

The technique, which triggers off of photons collected in situ from an individual fluorescing nanoparticle, provides high resolution three-dimensional position information with excellent time resolution and with the added benefit of sensitivity to chemical activity. Particles ranging in size from 20 nm to 2000 nm were followed in real-time as they diffused freely in water and over the curved surfaces of variously-sized oil droplets. As expected, the diffusion coefficients scaled with particle size for the freely diffusing particles. However, there was a significant and unexpected decrease in the diffusion coefficients for smaller (

Furthermore, for a given particle size, the researchers observed a large

spread in the diffusion coefficients measured at the interface, while no such effect was observed for the freely diffusing particles. In order to better fit the measurements, the basic model that works well for larger particles diffusing at a fluid-fluid interface needed to be modified to account for line tension (the one-dimensional analogue of surface tension) at the interface between the smaller nanoparticles, the oil, and the water.

The researchers believe that the variability in the diffusion coefficients of the particles adsorbed at the interface is most probably a reflection of subtle variations in the surface chemistry of the particles, suggesting that diffusion measurements may provide a new way to compare particle surface chemistries. Whereas following the dynamics of isolated particles provides many useful insights into their behavior, typical man-made and natural systems are usually far more complex, with heterogeneous fluids, crowded environments, and strong particle-particle interactions.

The researchers believe that using real-time, three-dimensional particle tracking to observe intentionally inserted, single tracer particles may provide an ideal tool to probe complicated fluid systems, such as the interior of cells, or oil/water mixtures trapped inside porous rock.

More information: Three-dimensional real-time tracking of nanoparticles at an oil–water interface, K. Du, J. A. Liddle, and A. J. Berglund, *Langmuir* 28, 9181–9188 (2012). pubs.acs.org/doi/abs/10.1021/la300292r

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