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Nanoparticles in liquid crystals, and liquid crystals in nanoparticles

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Liquid crystals are remarkably sensitive to interfacial interactions. Small perturbations at a liquid crystal interface, for example, can be propagated over relatively long length scales, thereby providing the basis for a wide range of applications that rely on amplification of molecular events into macroscopic observables. Our recent research efforts have focused on the reverse phenomenon; that is, we have sought to manipulate the interfacial assembly of nanoparticles or the organization of surface active molecules by controlling the structure of a liquid crystal. This presentation will consist of a review of the basic principles that are responsible for liquid crystal-mediated interactions, followed by demonstrations of those principles in the context of two types of systems. In the first, a liquid crystal is used to direct the assembly of nanoparticles; through a combination of molecular and continuum models, it is found that minute changes in interfacial energy and particle size lead to liquid-crystal induced attractions that can span multiple orders of magnitude. Theoretical predictions are confirmed by experimental observations, which also suggest that LC-mediated assembly provides an effective means for fabrication of plasmonic devices. In the second type of system, the structure of a liquid crystal is controlled by confinement in submicron droplets. The morphology of the liquid crystal in a drop depends on a delicate balance between bulk and interfacial contributions to the free energy; that balance can be easily perturbed by adsorption of analytes or nanoparticles at the interface, thereby providing the basis for development of hierarchical assembly of responsive, anisotropic materials. Theoretical predictions also indicate that the three-dimensional order of a liquid crystal can be projected onto a two-dimensional interface, and give rise to novel nanostructures that are not found in simple isotropic fluids.