Forming hollow nanoparticle microstructures via double nematic nucleation

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Rapid bulk assembly of nanoparticles into microstructures is challenging, but highly desirable for a variety of applications in controlled release, catalysis, and sensing. In recent work our group has developed a new method to form hollow microstructures using a two-stage liquid crystal nucleation process, generating size-tunable closed-cell foams, spherical shells, and tubular networks composed of closely packed nanoparticles. To achieve the structures, mesogen-modified nanoparticles are dispersed in liquid crystal above the nematic-isotropic transition temperature (TNI). On cooling through TNI, nanoparticles first segregate into shrinking isotropic droplets where they locally depress the transition temperature.

On further cooling, secondary nematic domains nucleate inside the nanoparticle-rich isotropic domains, driving the formation of hollow nanoparticle assemblies. We achieve structural differentiation using nanoparticle density and cooling rate. Our methods take advantage of the interaction between particle shape, surface anchoring and liquid crystal elasticity.

Using liquid crystal as a novel anisotropic solvent for nanoparticles opens up a wide range of possibilities for bulk structure templating via phase nucleation and growth.