Reversible 3D Assembly of Gold Nanoparticles in Blue Phase Liquid Crystals

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Gold nanoparticles (NPs) with diameter 4.5 nm, functionalized to be highly miscible in cyanobiphenol-based liquid crystals1, were dispersed in cyanohexyloxybiphenol (6OCB) and 4-cyano-4'-(2-methylbutyl)-biphenyl (CB15) blue phase (BP) mixtures (with 6OCB:CB15 ratios of 60:40, 50:50, and 55:45) and characterized by optical microscopy and synchrotron X-ray scattering. The gold NPs disperse in the isotropic and blue phases up to concentrations of 25 wt % Au. Similar to other gold NP-BP studies,2 the BP temperature range, ΔT, increased from 0.9 °C to ~2.5°C. Small angle X-ray scattering (SAXS) reveals that the gold NPs reversibly assemble into large periodic structures upon cooling from the isotropic to blue phase, as manifest by the appearance of a series of very sharp Bragg diffraction peaks. The Bragg peaks vanish in the cholesteric phase and reversibly re-appear upon temperature cycling. Analysis of the X-ray scattering indicates a population of randomly dispersed NPs co-existing with a cubic crystal arrangement of NPs. In the cholesteric phase, the NPs appear to separate into large regions, co-existing with cholesteric LC with reduced NP concentrations. In the BP, we propose that the gold NPs selectively migrate to the high energy sites of the BP defect structures, similar to the proposed mechanism for BP templating of photonic colloidal crystals.3 The gold NP lattice spacings vary with the pitch, controlled by the 6OCB:CB15 composition.

Fig. 1 Polarized optical micrographs and SAXS scattering curves of gold NP-BP dispersions. Nanoparticle concentration, LC phase and 6OCB:CB15 ratio are indicated.

References:

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