Electric Characterization of Liquid Crystal Nanocolloids

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Statement of Purpose: Liquid crystals are materials that exhibit features of both liquid and crystalline phases. Liquid crystal molecules are well known for their unique properties in responding to external stimuli such as optical and electric and magnetic fields. Liquid crystal nanocolloids (LCNC) are formed by confining liquid crystal molecules into nano volumes using surfactants together with a sponge like polymer network. These LCNC particles are isotropic in shape but with anisotropic physical properties. By incorporating molecular dipoles, fluorescent molecules and other functional molecules, LCNC particles can find a wide range of potential applications in areas such as nanoactuation, optical sensors, photonics, and controlled release. In this study, a novel experimental approach was designed to investigate the response of liquid crystal molecules in a single LCNC particle to an external electric field.

Methods: Scanning Kelvin Force Microscopy (KFM) and Electrostatic Force Microscopy (EFM) are used to characterize the electric response of liquid crystal molecules in a single LCNC nanoparticle. LCNC particles are synthesized using a mini-emulsion process, and are deposited on to a Au/Mica substrate. An electric field is applied between the Au substrate and the Pt coated KFM probe. The electrostatic force and the surface potential are measured.

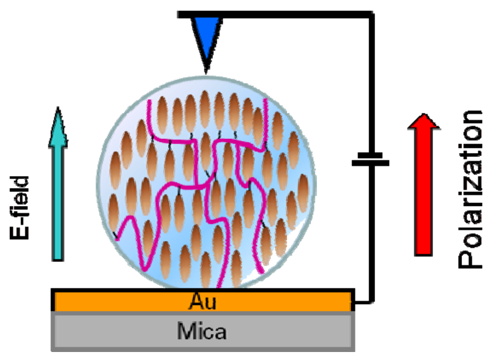

Figure 1. EFM and KFM setup for the characterization of electric response of LCNC particles

Results: Topography images revealed those LCNC particles are about 100 nm in size. EFM imaging shows significant contrast between the particles and the Au substrate, suggesting the liquid crystal molecules in the LCNC align themselves with the applied external electric field. The electrostatic force measured is linear at small bias but levels off at higher bias. This indicates a nonlinear polarization behavior of the LCNC at high voltages, or the presence of a limit of the number of molecules switchable. KFM experiment shows no significant difference between the particles and the Au substrate. However, potential difference was observed immediately after the particles were polarized by an external field. The measurements also show the potential induced by an external field has a typical decay time of 15-20 seconds.

Conclusions: KFM and EFM are powerful techniques for characterizing electric properties at the nanometer scale. We have successfully measured the electric response of liquid crystal molecules in a single LCNC particle. We have observed the reorientation and the relaxation of liquid crystal molecules under external field. The response of the LCNC particles to external field becomes nonlinear at high voltages.