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Field-assisted assembly and orientational order of colloidal ellipsoids

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Colloidal particles with anisotropy in shape and interactions can potentially be assembled into colloidal crystals with unusual structure and symmetry. Field-assisted assembly is likewise a means to produce structures that are otherwise difficult to achieve by equilibrium self-assembly. Here we show, by means of confocal microscopy direct visualization, how controlled application of electric fields can improve general prospects for assembly of any anisotropic colloid. By studying the model case of ellipsoidal colloidal rods, we find that applied fields can be designed which produce liquid crystal phases of colloids in a simple, versatile manner. By directly visualizing the assembled particles in three dimensions we learn that the quality of orientational order achieved is comparable to that of materials such as liquid crystalline polymers. We understand the results in terms of the underlying electrokinetics of the system as well as connect the observed field-induced orientational order to the equilibrium isotropic-nematic transition predicted for rods with prolate spheroidal shape. Specifically, the applied field generates a force that is balanced by a gradient in osmotic pressure generated by the density dependence of the rod suspension. If the field strength is sufficiently large, the resultant osmotic pressure produces a phase transition. We discuss how the required field conditions for assembly can be tailored based on the shape and size of the anisotropic building block.