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Spontaneous and guided self-assembly of clay nanoplatelets

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We study (i) spontaneous phase separation and nematic self-assembly in gravity of synthetic clay particles in aqueous suspensions, and (ii) guided self-assembly into chainlike structures of polarized clay particles in oil suspensions (electrorheological behavior). Experimental techniques used are synchrotron X-ray scattering, rheometry and microscopy. We demonstrate that clays may be used as good model systems for self-assembled soft and complex matter, and we give examples of interconnected complex physical phenomena in such systems. Self-assembly in clays may have practical relevance for nano-patterning, properties of nanocomposites, and macroscopically anisotropic gels.

1 Introduction: Synthetic fluorohectorite clay.

We report on experimental studies of the synthetic clay fluorohectorite, which belongs to the 2:1 type clays (generic terms: Swelling clays, smectite clays). The fundamental level of description for the 2:1 clays is at the mesoscopic scale. i.e. 1 nanometer thick platelets with effective platelet diameter in the 20 nanometer to 10 micrometer range, The platelets have charged surfaces (negative) and edges (small positive), and there are counter ions present in order to compensate for the charges. Our fluorohectorite particles are stacked, and consist of about 100 platelets, resulting in lamellar particles of about 100 nm thick, which thus constitute our "basic building blocks".

2 Spontaneous selfassembly of liquid crystalline structures of fluorohectorite clay nanoparticles in aqueous suspension [1].

We have made visual observations of spontaneous self-assembly and gravitational phase-separation of 100 nm -thick Na-fluorohectorite platelet particles suspended in salt (NaCl) water. Our visual

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studies suggest that a spontaneously formed nematic to isotropic structural transition occurs above a sedimented phase. These conclusions have been confirmed and strengthened through synchrotron x-ray scattering experiments. We have studied this phase behavior versus ionic strength, and we may be able to observe a transition from an electrostatically repulsive to an attractive (combined electrostatic repulsion and van der Waals attraction) nematic, in this system.

3 Guided self-assembly and smart material behavior of fluorohectorite clay nanoparticles suspended in oil [2].

We are using the same fluorohectorite particles as described above, but instead of immersing in water, we immerse in oil, and apply electric fields to the suspension, thus polarizing the suspended clay particles, which in turn form chains in between electrodes (defining the electric field geometry) due to dipolar interactions. We have studied this behavior using optical microscopy and synchrotron scattering techniques. We have investigated time scales for polarisability of clay particles, and determined the directions of easy polarisability of clay particles; we have also determined distributions of relative orientation of clay particles inside dipolar chains, and the field strengths needed for chain formation. In addition to the structural investigations, we have measured both mechanical yield strength, and flow viscosity of this electro-rheological system.

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