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Goethite: extraordinary mineral liquid crystals

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Goethite (α-FeOOH) can be synthesized as boardlike crystalline nanorods (of typical dimensions 200 x 40 x 20 nm^3 which can be varied over a wide range). These particles can be stabilized electrostatically in water of pH=3. Dispersions of these particles display the richest liquid crystal phase behaviour found in mineral liquid crystals, forming different nematic, columnar [1] and smectic [2] phases. We employed (microradian) small-angle x-ray diffraction at 2 different beamlines of the European Synchrotron Radiation Facility to investigate these different structures.

These mineral particles can be very polydisperse (above 50%), but alternative synthesis methods and repeated centrifugation steps can be used [3] to reduce their polydispersity to about 15%. We will discuss the important role sedimentation and fractionation play on the occurrence of the different LC phases for systems of different polydispersities [4]. In the special case that the width of the particles is the geometric mean of their length and thickness, we recently identified biaxial LC phases.

Finally, Goethite particles also show interesting magnetic properties. They possess a permanent magnetic moment along their long axis combined with an induced moment with an easy axis along the shortest particle dimension. This combination leads to an extreme sensitivity to magnetic fields and peculiar re-orientation phenomena when the strength of the external magnetic field is varied. We show this can even lead to magnetic-field induced phase transitions.

[1] B. J. Lemaire *et al, Phys. Rev. Lett.* **88**, 125507 (2002)
[2] G. J. Vroege *et al*, *Adv. Mater.* **18**, 2565 (2006)
[3] D. M. E. Thies-Weesie *et al, Chem. Mater.* **19**, 5538 (2007)
[4] E. van den Pol *et al, J. Chem. Phys.* **129**, 164715 (2008)