DUBBLE	**Experiment title:** Modified Goethite liquid crystals in external magnetic fields	**Experiment number**: **26-02-393**
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Report: (max. 2 pages)

Goethite particles show interesting magnetic properties [1]: they possess a considerable permanent magnetic moment along their long axis, presumably due to uncompensated spins within their anti-ferromagnetic crystal structure, combined with an induced magnetic moment with an easy axis along the shortest particle dimension.

One of the main goals we hope to achieve in this project is to find ways to tune these opposing types of magnetic behavior by changing the relative importance of the permanent moment and the induced moment. Last year some preliminary measurements were done with goethite modified with chromium (Cr) [2]. One of the problems with those measurements was that the magnetic field that could be reached was not high enough (max. 0.6 T). Furthermore, the systems with and without Cr were not really comparable (different polydispersity and history of the samples).

In the present measurement session at DUBBLE a magnetic field up to 1.4 T could be reached with the variable permanent magnet of ID02. Systems with 0 %, 3 % and 6 % Cr substituted for Fe of similar dimensions (L x W x T) and similar relative polydispersity were used to study their behavior (Table 1):

Table 1: Particle dimensions of goethite with different Cr concentration.

% Cr	L (nm)	σ_L (%)	W (nm)	σ_W (%)	L/W
0	240	23	61	23	4.0
3	243	18	65	17	3.8
6	230	16	70	15	3.3

Capillaries were filled with different volume fractions of goethite. In all systems isotropic-nematic phase separation was observed from a certain volume fraction. The microradian setup [3] with compound refractive lenses was used to record SAXS patterns at different positions in the samples and at different magnetic field strengths. In this way the behavior of the particles was studied in the different phases, also depending on the concentration.

At B = 0 T an isotropic scattering pattern can be seen for all the systems, measured a few mm above the I-N interface (Figure 1). There seem to be more correlations between the particles with increasing Cr concentration. This can be seen as a more pronounced ring in the scattering pattern and a sharper peak in a slice through the scattering ring (Figure 2).

Upon application of the magnetic field the isotropic phase gradually transforms into an anisotropic (para-nematic) pattern, consistent with the long axes of the particles aligning along the field direction. At higher field strengths the particles align with their shortest dimension along the field and thus the longest dimension perpendicular. The field at which the particles turn perpendicular increases with increasing Cr concentration. For pure goethite the field where the process starts is around 200 mT, for 3% Cr around 450 mT and for 6% Cr around 700 mT.

The same measurements were done for the nematic phase. The same trend was found; more detailed analysis is currently conducted. For example, we are looking at the influence of the height in the sample and of the volume fraction of the sample.

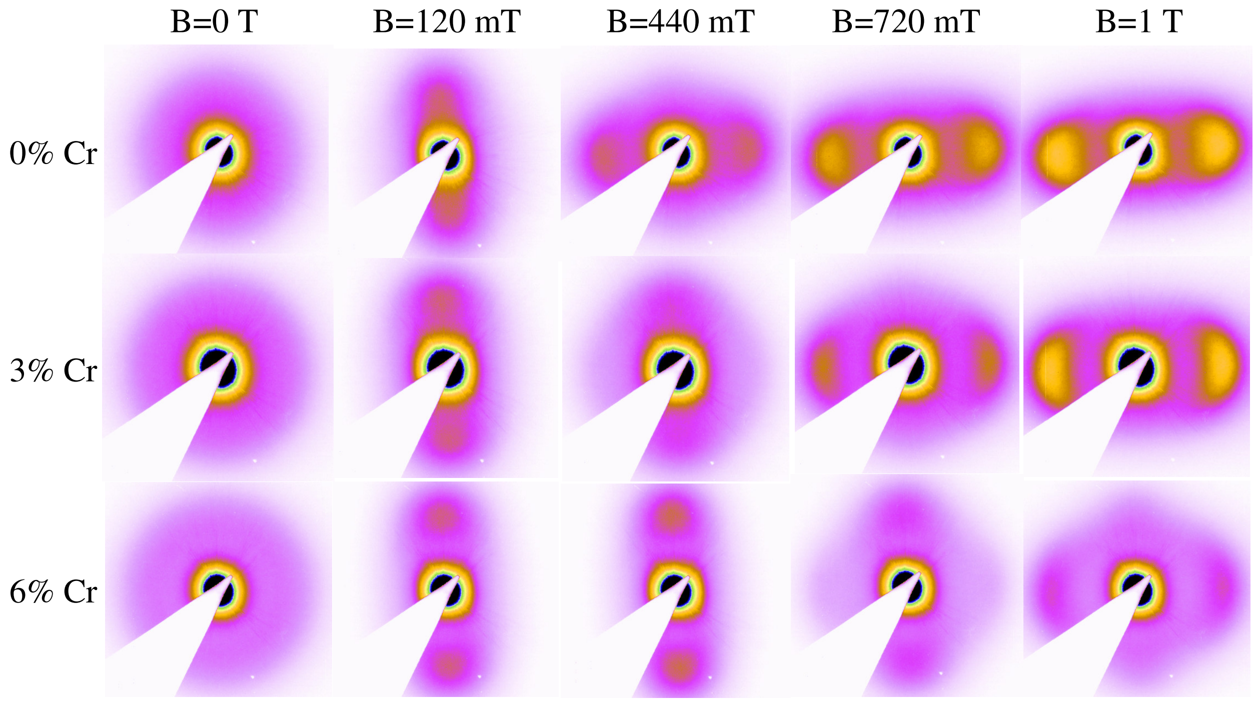

Figure 1: SAXS patterns of goethite with different Cr concentrations in a magnetic field.

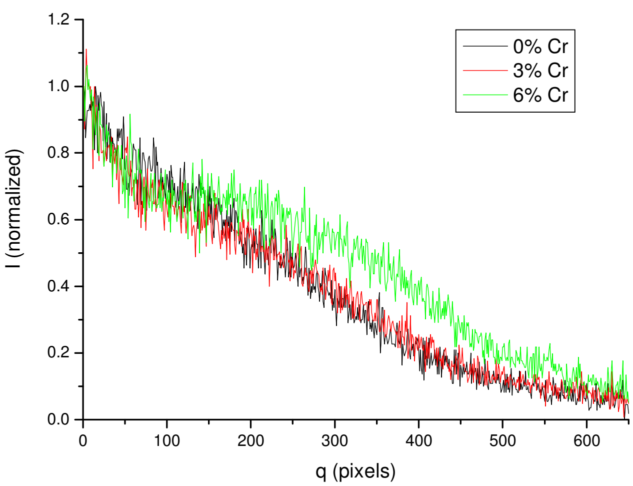

Figure 2: Slice through the isotropic scattering pattern.

Other topics studied during this measurement session are goethite modified with aluminum and cobalt, uncharged goethite and the influence of polydispersity.

With the magnet we used it is also possible to change the poles to change the direction of the magnetic field from perpendicular to parallel to the beam. This gives us some extra information on what is going on in 3D.

[1] B.J. Lemaire *et al*, Phys. Rev. Lett. **88**, 125507 (2002).
[2] Experimental report 26-02-345
[3] A.V. Petukhov *et al*, J. Appl. Cryst. **39**, 137 (2006).