ESRF	**Experiment title:** Electrorheological chain formation in synthetic nano-layered silicates	**Experiment number:** SC-1481
Beamline: BM26B	**Date of experiment:** from: 21/04/2003 to: 23/04/2003	**Date of report:** 26/09/2003
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Scientific background – motivation for the study :

Electrorheological fluids have the property of displaying drastic changes in their rheology when exposed to a sufficiently intense electric field. The simplest form of electrorheological fluid is a suspension of polarizable particules immersed in a non-polar fluid [1]; Dipolar interaction between polarized particles is responsible for their aggregation along chains parallel to the electric field [1]. Nano-layered silicate suspensions, or clay suspensions, on the other hand, are colloidal suspensions of platelets that display a complex phase behavior depending among other things on the concentration in colloids, ionic strength of the solvent, and particle sizes. These properties have been investigated theoretically and experimentally using many techniques [2], among which synchrotron X-ray scattering methods [3, 4].

Microscope observations carried out in our laboratory at NTNU in Trondheim (Norway) on suspensions of fluorohectorite clays showed evidence of an electrorheological behavior for an electric field of a few kV/mm [5]. Fluorohectorites are synthetic swelling clays with a formula X_x-$Mg_{3-x}Li_xSi_4O_{10}F_2$. The colloidal particles consist of a stacking of ~ 100 silicate platelets that are bonded together by an interlayer cation X, the nature of which influences the strength of the bonding and the interaction between particles in the solvent. Cations and water molecules can be intercalated between the platelets, which plays a role in the polarizability of the particles.

In the spring of 2003 we performed WAXS experiments using the 2D MAR detector at BM01A. From this data we determined the orientation of the particles in our electrorheological chains, and showed that they polarize along the nanosilicate sheets [5]. The study of the orientational distribution showed a pseudo-nematic orientational ordering inside the nematic chains [6]. The series of SAXS experiments presently reported was planned so as to obtain further information regarding that ordering, in particular to see whether there would also be ordering in the particle positions inside the chains.

Experimental method:

The three types of samples consisted of fluorohectorite (X=Na, Ni and Fe) particles immersed in a silicone oil (viscosity 100 cSt). They were investigated by Small Angle X-Ray Scattering, using a wavelength $\lambda = 0.65$ Å and a camera length $D \sim 8$ m. A cell that we specially designed allows to apply a high voltage E between 2 copper electrodes, between which the sample is contained. At room temperature, an electric field ~ 1 kV/mm was applied between the electrodes, after which a series of 2D SAXS picture was recorded until the system was observed to be stabilized in its electorheological "organized" state. This was repeated for the three types of initially "wet" (1 or 2 layers of intercalated water) samples.

The 6 shifts of beam time awarded were fully utilized. More time would have been needed in order to perform experiments at different magnitudes of the electric field.

Results obtained:

The data presents no evidence of a correlation peak in the investigated q-range. This indicates that the distribution of particle positions inside the electrorheological chains is random. The smallest momentum transfer available, however, corresponds to a length scale around 0.5 μm, which is of the same order of magnitude as the particle size along the silica sheets. The data is now being analyzed with respect to the asymptotic behavior at intermediate q values: the slope of the power law should yield information on the geometry of the porous space between the particles, inside the electrorheological chains.

References

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