Magnetic nanofluids with mixed surfactant layers

Doina Bica [1], M.V. Avdeev [2], Oana Marinica [3], V.M.Garamus [4], L. Vékás [1,3]

[1] *Laboratory of Magnetic Fluids, CFATR, Romanian Academy, Timisoara Division, Timisoara, Romania*
[2] *Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia*
[3] *National Center for Engineering of Systems with Complex Fluids, Univ. Politehnica, Timisoara, Romania*
[4] *GKSS Research Centre, Geesthacht, Germany*

Long-term colloidal stability of magnetic nanofluids, especially at high volume fraction of magnetic nanoparticles, is a complex issue connected to the synthesis procedure followed, including the nature of surfactant(s) and carrier liquids used [1,2]. The dimensionless coupling parameter λ, which is half the ratio of the dipolar energy of two aligned dipoles at close contact to the thermal energy, should be kept below 1 to ensure highly stable magnetic fluids. During preparation repulsive forces due to coating of magnetic cores are introduced to prevent irreversible aggregation of particles produced by attractive van der Waals and dipolar interactions. When the dipolar interactions are much stronger than the thermal energies, particle chains start growing and forming more complex structures, depending on the particle volume fraction, size distribution, temperature and magnetic field applied.

An interesting feature of magnetic nanofluid synthesis is that the relative strengths and ranges of various interaction potentials can be controlled by the diameter of magnetic cores and the thickness of the surfactant layer.

In this paper non-polar organic liquid based magnetic nanofluids (MNFs) will be considered, having magnetite nanoparticles coated with various chain length surfactants, such as lauric acid (LA), myristic acid (MA) and oleic acid (OA), as well as their mixtures. These acids show different efficiency in dispersing different size-fractions of nanometric magnetite particles. While oleic acid is proved to be highly efficient surfactant to stabilize nanomagnetite over the wide size interval of 2-20 nm, shorter fatty acids stabilize partially this interval dispersing in the carrier only a fraction of smaller particles. Nevertheless, it should be pointed out that the resulting nanofluids are as highly stable in strong magnetic field (up to 2.5 T in our SANS experiments) as the samples stabilized by oleic acid.

Taking into account that the considered surfactants are well miscible in bulk liquids, one can expect that a similar property takes place at the interface with magnetite particles. Thus, the synthesis of magnetic fluids with regulation of particle size distribution can be realized with the help of mixtures of fatty acids. Our first structural investigations of magnetic fluids prepared with mixtures of different fatty acids confirm this and point out the fact that the characteristic size of the magnetite particles can be changed during the synthesis in the range of about 4-10 nm.

The effect of tailoring the stabilizant layer thickness is illustrated by the relative full magnetization curves in Fig.1 for four

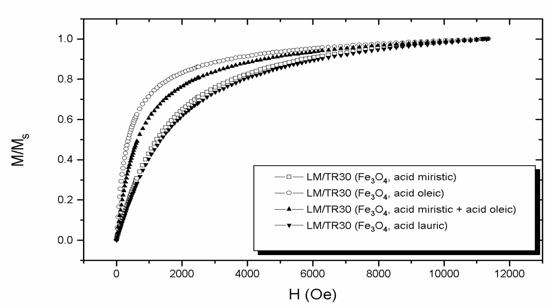

Figure 1.

samples of transformer oil based magnetic fluid samples, stabilized with different chain length surfactants, LA, MA and OA. Mixing of surfactants of different chain lengths, MA: OA= 1:1, conducted to a rela-

tive magnetization curve situated between those corresponding to samples with LA (or MA) and OA monolayer.
The size regulation effect is also seen in small-angle neutron scattering curves from D-benzene based samples with MA, OA and their mixtures (Fig.2), which result in different magnetite size distribution, $D_N(R)$.

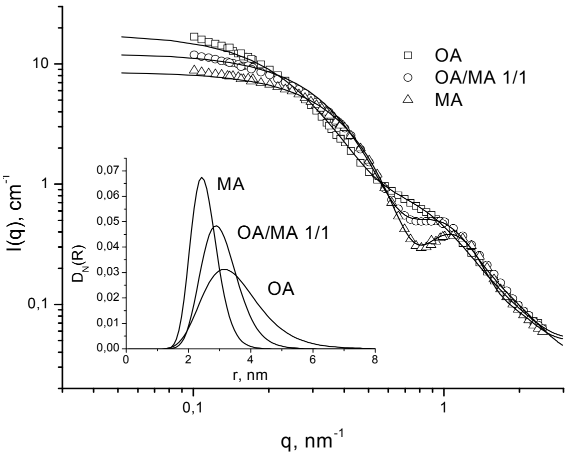

Figure 2.

These findings are in agreement also with magneto-rheological investigations. All the samples show Newtonian behaviour in magnetic field, while the field induced viscosity change is rather small (up to a few percent), especially in the cases of LA and MA stabilized samples.
Further investigations about the behavior of the mixed surfactants at the particle surface are planned.

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