Structuralization in magnetic fluids after light illumination

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Introduction

The formation of the magnetite nanoparticle structuralization in the magnetic fluids is observed as a consequence of the nanoparticle concentration diffusion and thermo-diffusion. The temperature gradients can arise due to light-absorption on the accidental concentration fluctuations of particles or on the well defined geometric structure such as the concentration- diffraction grating. From the time dependence of the grating decay it is possible to determine the sign of the thermo-diffusion Soret coefficient S. Different techniques have been used to determine the Soret constant, particularly based on the thermodiffusion columns [1], on the forced Rayleigh scattering (FRS) [2] or on the Z-scan technique [3], commonly employed to investigate the nonlinear properties of a medium, allowed to make a classification of magnetic fluids based on the stabilization type, surfactant and carrier liquid. The nanoparticle structuralization and its decay after additional illumination in the mineral oil and kerosene based magnetic fluids connected with the nano-particle thermo-diffusion are presented in the paper.

Experiment

For experiment we have used two types of magnetic fluid based on mineral oil with magnetite particles covered by oleic acid as mono-layer surfactant and kerosene magnetite particles sterically stabilized by double layer consisting of oleic acid and dodecylbenzensulphonic acid (DBS) with Fe_3O_4 as a magnetic carrier. The later one used surfactant is anionic thus according to Alves [3], the Soret constant of studied magnetic fluid should be negative and the structuralization of the particle concentration should be observed in illuminated sample.

Results and discussion

In the sample which is illuminated by an external homogeneous light field the structuralization will arise, if the stochastic inhomogeneities are presented in the sample. This is due to arising of the temperature by the different absorption of light in such places. Figure 1 illustrates the situation in

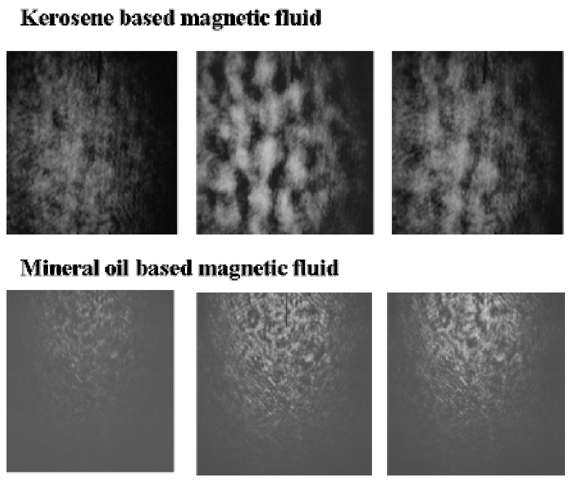

Figure 1: The development of the structure after illumination with "islands" of enhanced concentration in kerosene-based magnetic fluid and without structuralization in mineral oil-based magnetic fluid.

kerosene- and mineral oil-based magnetic fluid samples at increasing intensity. It is evident, that in kerosene based magnetic fluid the structure with "islands" of enhanced concentration has developed. This indicates the negative value of the Soret constant of the kerosene-based magnetic fluid.

It is convenient to study the kinetics of nanoparticles using the predetermined structure of the light field. Such structure may be for instance a grating formed by use of two crossed coherent laser beams interfering in places of their intersection. The sample of the colloidal liquid in form of the thin layer (thickness about 60 μm) was inserted into the interference field and the periodic thermal field was such formed. Due to the diffusion and thermo-diffusion

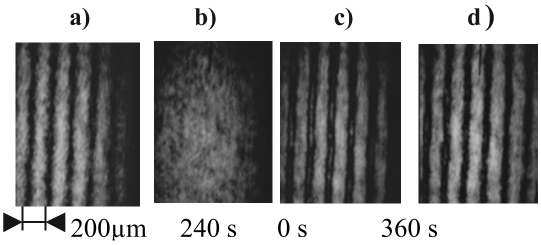

Figure 2: The structure decay after switching off of interference field without (a,b) and with (c,d) additional light illumination, respectively.

of the nano-particles the concentration diffraction grating with period of 200 μm will be created. According to behavior of the time dependence of the grating decay (after switching off the interference field and under presence of the additional lighting), it is possible to determine the sign of the thermo-diffusion coefficient S too.

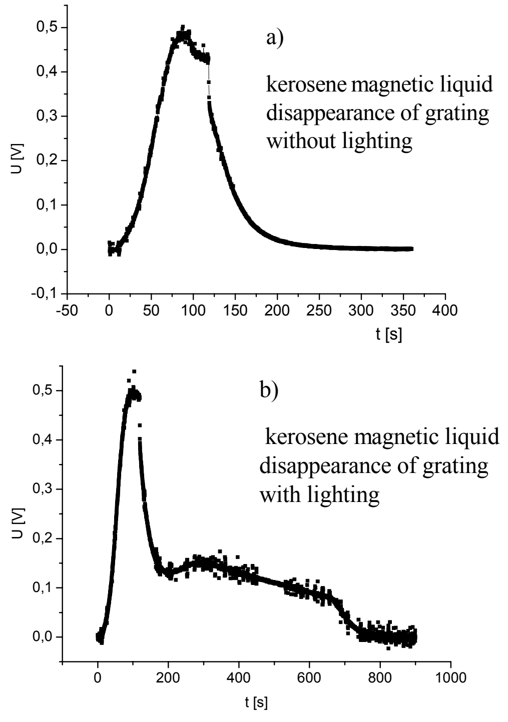

Figure 3: The time dependence of diffraction intensity corresponding to grating decay without (a) and with (b) additional light illumination, respectively.

The grating created in the mineral oil based magnetic field (*S*>0) will decay in the same way independently on the fact of its additional illumination (Fig.2b). The same process of the decay without additional illumination is observed in kerosene based magnetic liquid (S<0) what corresponds the time dependence of diffraction intensity (Figure 3a) after switching off of interference field. Completely different dependence of concentration decay is observed in case of additional illumination (Figure 2d). The concentration grating is observable after 360 s and the time dependence of diffraction intensity (Figure 3b) shows that thermodiffusion flux will prevail over the diffusion flux and the grating decay will be slowed down, eventually the grating will be reconstructed (another maximum in Figure 3b at 300 s).

Conclusion

To conclude it can be said, that the obtained results indicated the negative value of the Soret constant in studied kerosene-based magnetic fluid. It proved to be convenient to investigate the kinetics of the nano-particles in the dispersion liquid on the well defined geometric structure such as the concentration diffraction grating. From the time dependence of the grating decay it is possible to determine the sign of the thermo-diffusion coefficient S.

Acknowledgments

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