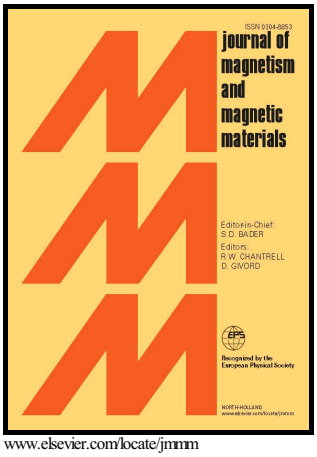

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STRUCTURAL ASPECTS OF MAGNETIC FLUID STABILIZATION IN AQUEOUS AGAROSE SOLUTIONS

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Abstract. Structure characterization of magnetic fluids (MFs) synthesized by three different methods in aqueous solutions of agarose was done by means of small-angle neutron (SANS) and synchrotron X-ray scattering (SAXS). The differences in the complex aggregation observed in the studied magnetic fluids were related to different stabilizing procedures of the three kinds of MFs. The results of the analysis of the scattering (mean size of single polydisperse magnetic particles, fractal dimensions of the aggregates) are consistent with the data of transmission electron microscopy (TEM).

Keywords: Magnetic fluids, ferrofluids, aggregate structure, aqueous solutions, agarose, small-angle scattering, transmission electron microscopy.

1. INTRODUCTION

Many attempts are made in present-day materials science to improve the methods of controllable synthesis of complex colloidal systems containing nanoparticles with a characteristic size in the range of 1-100 nm. In particular, this concerns magnetic fluids where magnetic nanoparticles (MNPs) with a single-domain state of magnetization are dispersed and stabilized in liquid carriers. MNPs have much prospect in biology and medicine due to their promising applications including magnetic contrast agents in diagnostics of various diseases by magnetic resonance imaging [1,2] as well as magnetic drug delivery complexes or hyperthermia inductors in the cancer treatment therapy [3,4]. For these purposes magnetic nanoparticles should be non-toxic and demonstrate superparamagnetic behavior. However, these features can be affected by aggregation processes during the synthesis of MFs, so that the final macroscopic properties of the systems can vary greatly depending on the self-organization of MFs at the nanoscale. Thus, the detailed characterization of the MF nanoscale with respect to the stable aggregate formation allows one to control macroscopic properties and widen the range of potential practical applications. In this respect, small-angle scattering is one of the actively used method to probe at the nanoscale the structure of various complex colloidal solutions including magnetic fluids [5,6].

The fully controllable synthesis of stable aqueous magnetic fluids with predefined properties is still a problem. The aggregation stability of these systems strongly depends on the method of synthesis and the conditions of preparation, as well as on the surfactants used for stabilization and their amount in MFs. Thus, it has been shown that the kind of surfactants as well as different additives can lead to various structural organizations in MFs [7,8]. Also, an important moment is the synthesis of biocompatible magnetic fluids. In this case MNPs are covered with non-toxic stabilizing shells of organic or inorganic molecules introduced into biocompatible media either prior to or in the process of dispersion of MNPs. Aqueous solutions of agarose ($C_{12}H_{18}O_9$) are frequently used to model biological tissues in biomedical tests with MNPs [9-11]. In particular, this is due to the fact that their rheological properties are similar to those of biological media [12]. From the viewpoint of colloidal stability, the presence of agarose in the carrier is expected to prevent to some extent the aggregation of MNPs because of an increase in the viscosity of the carrier, which slows down the mobility of nanoparticles.

The aim of this work was to study the structure of magnetite MNPs dispersed directly into a biocompatible viscous medium based on a water-agarose solution and compare from the structural viewpoint three different methods of synthesis of MFs. The structure characterization of MFs was