Search for Order in Magnetic Dispersions: II. SANS

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Abstract

Numerical order of 200 nm long polydispersed nanoparticles in a magnetic dispersion (3.9 vol. % Fe particles in cyclohexanone) has been investigated by small angle neutron scattering. We have observed sinusoidal oscillations of the scattering intensity, which exhibit interesting rheological properties (viscosity), demonstrating that the particles are oriented in a shear flow and the order in the magnetic field.

Introduction

Magnetic liquids have applications in automobiles and magnetic data storage media such as the tape.

Orientational order of 200 nm long polydispersed nanoparticles in a magnetic dispersion (3.9 vol. % Fe particles in cyclohexanone) has been investigated by small angle neutron scattering. We have observed sinusoidal oscillations of the scattering intensity, which exhibit interesting rheological properties (viscosity, etc.) in a shear flow, electric field and magnetic field. Understanding of the orientational order in a dispersion subjected to either shear or magnetic field can lead to a better design of magnetic fluids and novel applications.

Small angle neutron scattering (SANS) can be used to investigate the order in magnetic dispersions. Details of our previous experimental and theoretical work in dispersions can be found in Ref. 1.

The scattering anisotropy is sinusoidal, characteristic of the magnetic anisotropy and the shape anisotropy of the particles when they are oriented in the applied magnetic field.

Conclusions

Initially, large anisotropy appears as the particles order in the field. When shear is applied the particles lose their orientation. At a characteristic shear rate of 310 s⁻¹, the particles reorient themselves into the shear flow direction.

The degree of ordering can be continuously varied with the shear flow, whereas, the individual orientation of the particles can be essentially in two directions; (i) along the applied field or (ii) along the shear flow.

Small angle neutron scattering from a magnetic dispersion of polydispersed nanoparticles subjected to shear flow and magnetic field shows that the desired degree of orientational order can be achieved.

Top figure shows the degree of order in the dispersion is irreversible. Bottom figure shows the field dependence of the tilt angle of the particles.

A cartoon showing the orientation of nanoparticles in the dispersion in a shear flow and in an applied magnetic field.

NG3 SANS with Shear Cell at NIST

SANS Experimental Geometry

Reference


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