Orientation dynamics of ferrofluids subject to rotating external fields

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The orientation and structure of ferrofluid fibrils subject to unidirectional and rotating magnetic fields have been studied using two optical methods: scattering dichroism and small angle light scattering (SALS).

We find that when a unidirectional magnetic field is applied, the ferro-particles experience an attractive dipolar interaction and form chains parallel to the applied field. The resulting anisotropic structures scatter light with a polarization dependence that leads to a dichroism. This optical effect is shown to be highly sensitive to the aggregation phenomena and is sufficiently fast to follow the kinetics of chain formation and relaxation. With these experiments we see that for low magnetic fields, the dichroism increases rapidly with increasing field intensity and ultimately reaches a plateau above a critical value of the field.

When a rotating field is imposed, we find that as we increase the applied field strength the dichroism increases. In addition, the orientation angle of the dichroism is observed to precisely track the rotation of the fibrils. However, we observe that the induced dichroism decreases as angular velocity of the field increases**,** being different the decrease rate above or bellow a critical frequency value**.** This decrease reflects break-up of the chains due to hydrodynamic friction as they rotate in the suspending fluid. In addition, the phase difference between the rotating chains and the magnetic field was measured as a function of the angular velocity of the field. We observe that the phase difference increases with frequency over the whole range of frequency. However, the phase difference is only a weak function of the magnetic field strength.

The SALS patterns from ferrofluids subject to magnetic fields show a bright streak as the light is scattered by chainlike structures aligned in the direction of the magnetic field. Measurement of time-dependent SALS patterns generated by ferrofluids in the presence rotating magnetic provides a means of measuring the dependence of the chain dimensions as a function of the magnetic field strength and frequency.