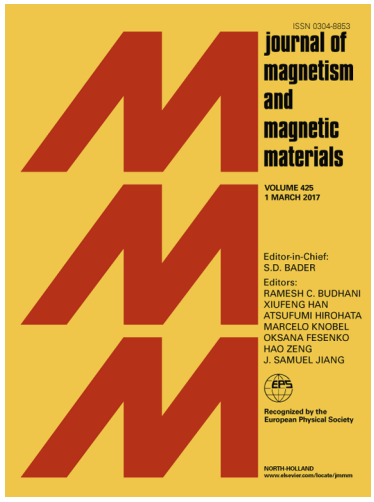

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Magnetic Detection of Nanoparticle Sedimentation in Magnetized Ferrofluids

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Abstract

Colloidal stability in external magnetic field is crucial for applications of ferrofluids. Here, we introduce a magnetic analysis approach to monitor how rapidly magnetic nanoparticles are pulled out of the liquid in an external magnetic field gradient. The motion of the sedimentation front is deduced from the time-dependent field produced by a column of ferrofluid placed on a permanent magnet. Citrate-stabilized nanoparticles in a homemade aqueous ferrofluid are found to sediment at the rate expected of single nanoparticles. More rapid sedimentation occurs in two other types of ferrofluid, indicating that our magnetic sedimentation analysis method can differentiate ferrofluids with respect to their in-field colloidal stability. Our method is further validated by comparison with time-dependent X-ray transmission profiles.

Keywords ferrofluids; magnetic nanoparticles; colloidal stability; sedimentation; X-ray transmission

Bullet points

1. Nanoparticles in a ferrofluid sediment in external magnetic field gradient.
2. Sedimentation changes the external magnetic field produced by magnetized ferrofluid.
3. Sedimentation rates were calculated from the measured external field of ferrofluids.
4. Sedimentation rates from X-ray transmission profiles validate our magnetic approach.

1. Introduction

Ferrofluids are concentrated colloidal dispersions of magnetic nanoparticles that behave as liquid magnets in external field. Oil-based ferrofluids are used as lubricants in many applications, with the advantage that they can be magnetically kept into place.[1-5] Another type of application of ferrofluids exploits the phenomenon of magnetic levitation: a nonmagnetic object that would sink in a normal liquid can be made to levitate in a ferrofluid, whose apparent mass density can be tuned via the magnetization of the fluid and via the magnetic field gradient.[5] Magnetic levitation has been applied for decades in the diamond industry, to separate diamonds from gangue material,[6] and currently, magnetic levitation is being developed as a technology to separate solid waste materials for recycling.[7] The separation of plastics by magnetic density separation requires new low-cost high-stability ferrofluids that are water based, to prevent the dissolution of plastic.