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Density Separation versus Dipolar Chaining of Magnetic Holes

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Magnetic fluids have a magnetically tunable apparent density which can be much higher than the fluid's normal density. Rosensweig revealed this phenomenon by floating a copper sphere on top of a ferrofluid,1 and industrial applications have been proposed to isolate diamonds [2] or gold [3] and to separate nonferrous metals from scrapped cars.4 However, early tests by Shimoiizaka et al.[5] showed that magnetic density separation of 'nonmagnetic'(diamagnetic) particles deteriorated below a cutoff size. A tentative explanation [5,6] was that the particles acted as 'magnetic holes',[7] forming dipolar structures containing particles of different densities, rather than being separated. An alternative, hydrodynamic explanation centers on the fact that gravity and magnetic forces scale with particle volume, whereas viscous drag scales with particle diameter. Consequently, small particles require more time to reach their equilibrium elevations than large particles, possibly longer than the particles are present in a separator.[8] In our own preliminary work, we indeed find that particle size is a key parameter deciding on the competition between density separation and dipolar chaining of 'magnetic holes'. Our research is motivated by ongoing efforts in the Dutch recycling industry (previously led by Umincorp, presently by Myne, see https://www.myne.eco/) to separate waste solid materials continuously into several density fractions using ferrofluids.[9,10]

1. R. E. Rosensweig, *AIAA J.*, 1966, **4**, 1751
2. L. L. Vatta, *Macromol. Symp.*, 2005, **225**, 221.
3. J. Svoboda, Magnetic Techniques for the Treatment of Materials, Kluwer Academic Publishers, New York, 2004.
4. T. Fujita, in *Magnetic Fluids and Applications Handbook*, Ed.: B. Berkovski, Begell House, New York, 1996.
5. J. Shimoiizaka, K. Nakatsuka, T. Fujita, and A. Kounosu, *IEEE Trans. Magn.*, 1980, **16**, 368.
6. S. Odenbach, *Magn. Electr. Sep.*, 1998, **9**, 1.
7. A. T. Skjeltorp, *Phys. Rev. Lett.*, 1983, **51**, 2306.
8. S. Tajfirooz, J. G. Meijer, R. A. Dellaert, A. M. Meulenbroek, J. C. H. Zeegers, and J. G. M. Kuerten, *J. Fluid Mech.*, 2021, **910**, A52.
9. L. Wang, P. Rem, F. Di Maio, M. van Beek, and G. Tomás, *Recycling*, 2024, **9**, 48.
10. B.H. Erné, 'Magnetic Density Separation', chapter in *Magnetoresponsive Soft Nanosystems*, part of the *Nanoscience and Nanotechnology* series, Editors S. Laurent and L. Vékas, Royal Society of Chemistry (book in production, expected to be published in 2026).

Type:

Poster