Ultrasound study of magnetic separation in Pickering and hybrid emulsions

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Magnetic emulsions combine efficient stabilization with external stimuli responsiveness. In particular, Pickering emulsions stabilized by iron oxide nanoparticles (IONPs) can serve as a platform for magnetically controlled filtration of (unwanted) substances. Using an external magnetic field, those systems can be heated and transported, their internal structure can be remotely changed, and they can undergo magnetic separation. While many studies focus on emulsions with particles located at the droplets' interfaces, hybrid emulsion systems—where magnetic nanoparticles are present both at the droplet surface and freely dispersed in the continuous or dispersed phase—may exhibit different separation behavior.

In this work, we investigate magnetic separation of oil-in-water and oil-in-oil emulsions stabilized by IONPs, as well as hybrid emulsion systems. Magnetic nanoparticles of different diameters are tested to evaluate the influence of their sizes on systems' stabilization efficiency and magnetic responsiveness. Separation experiments are performed for various magnetic field intensities and for different system internal structures.

To control systems' evolution during magnetic field exposure, ultrasonic measurements are applied as a non-invasive monitoring method, enabling tracking of internal changes such as droplet fragmentation and spatial redistribution. The obtained results help to identify how particle localization and size affect magnetically driven phase separation in tested systems, delivering a basis for the design of optimized magneto-responsive emulsion-based systems for future applications.