Effectiveness of Detergents Analysed Using Rotating Magnetic Nanoparticles

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Measurements of the effectiveness of detergents are important for both producers and consumers of detergents in the multi-billion global detergent market. Current methods of measuring detergent effectiveness involve the use of sedimentation and tergotometry, which are time-consuming, qualitative and energy-inefficient. In this project, a compact, low-cost and highly sensitive magnetic impedance spectrometer was customised to measure phase lag between an external rotating magnetic field and the rotation of Fe_3O_4 magnetic nanoparticles (MNPs) coated with polyvinylpyrrolidone (PVP). When MNPs are placed in a rotating field generated by orthogonal coils, a phase lag arises due to viscous drag force exerted by medium. This phase lag can be used to calculate the hydrodynamic volume of MNPs. Initially, the surfactants were expected to form micelles around the MNPs, just like how they would do around dirt, and increase the hydrodynamic volume of MNPs. Surprisingly, we found that the hydrodynamic volume of MNPs decreased with increasing detergent concentration. This led us to a discovery that the surfactants delaminate PVP from the MNPs, thus decreasing the hydrodynamic volume. Moreover, experiments conducted on 3 different types of detergents (alkaline, neutral, acidic) showed that the hydrodynamic volume of MNPs decreased with increasing detergent concentration which further substantiated the discovery. Thus, a whole new gateway has been opened for the commercialization of the technique to measure the effectiveness of detergents using MNPs. This innovative technique is quantitative, highly reproducible, environmentally friendly; using <1ml of test solution, cheap and fast, with each experiment taking only 10 minutes.

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