Developing Emulsion Additives to Optimize Rheological Behavior in Non-Aqueous Magnetorheological Smart Fluids

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Magnetorheological fluids (MRFs) are smart materials capable of rapid, controllable viscosity shifts when subject to magnetic fields. MRFs transition from a liquid to a semi-solid phase as ferromagnetic particles suspended within the carrier fluid align into chain-like structures when magnetized. Tunable viscosity performance enables MRF application in adaptable energy-damping systems, including rehabilitation prosthetics and seismic dampers. Current research demonstrates enhanced viscosity modulation in aqueous MRF systems when integrated with emulsions, leading to the development of novel magnetorheological emulsions (MREms). However, aqueous systems present significant challenges from instability and reduced durability in rust-prone metals. This study aimed to (1) formulate a stable, non-aqueous emulsion system to develop non-aqueous MREms and (2) compare the performance of developed MREms to traditional MRFs. A successful emulsion was formulated using silicone-based Polydimethylsiloxane emulsified in Glycerol and stabilized with Fumed Silica serving as a Pickering emulsifier. The manipulation of key characteristics—iron concentration, droplet size, magnetized soak time, and magnetic flux—revealed that MREms exhibit enhanced viscosity transformations under specific stress. Notably, MREms subjected to extended magnetized soak time and increased magnetic flux outperformed traditional MRF viscosity behavior. This study demonstrates that non-aqueous MREms can achieve superior performance and offer a more robust alternative to both aqueous MREms and non-aqueous MRFs. Future research should refine MREm formulations and investigate the potential for high-impact applications for industrial energy-damping.

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