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Dispersion Stability of Surface-Modified Magnetic Nanoparticles in CO_2-expanded liquids

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Carbon dioxide (CO_2) is a promising natural refrigerant and working fluid, but it does not inherently possess direct controllability by external fields other than temperature and pressure. In this study, the feasibility of creating a CO_2-based working fluid with magnetic responsiveness was investigated by introducing magnetic nanoparticles under liquid-to-supercritical CO_2 conditions. Oleic-acid-modified Mn–Zn ferrite nanoparticles were used, and their dispersion and aggregation behaviors under CO_2 introduction were directly observed using a high-pressure visualization system equipped with a windowed cell.

The experiments were conducted under three conditions: (1) direct exposure of nanoparticle powder to CO_2, (2) observation of state changes after introducing CO_2 into an n-hexane pre-dispersion of the particles, and (3) observation of dispersion-state changes under pressure sweep conditions using the n-hexane pre-dispersion. As a result, no clear dispersion was observed when the nanoparticle powder was directly exposed to CO_2 within the tested range. In contrast, for the n-hexane pre-dispersed samples, an apparently dispersed state was formed in the CO_2 environment under low-pressure conditions immediately after CO_2 introduction, as shown in Figure 1. Furthermore, in the pressure-sweep experiments, reversible dispersion transitions were observed: sedimentation and aggregation progressed upon pressurization, whereas redispersion occurred upon depressurization.

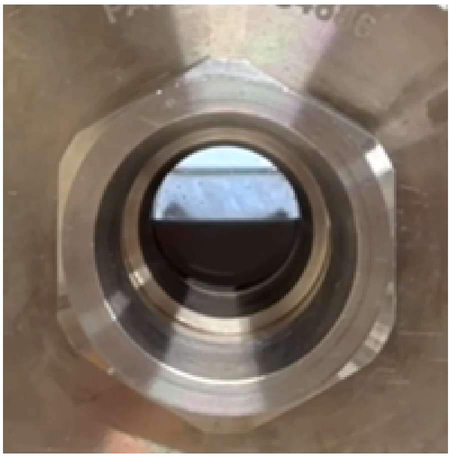

Figure 1:

These results revealed that, by employing a pre-dispersion process, magnetic nanoparticles can be introduced into a CO_2 environment to form a limited but observable dispersed state, and that this dispersion state responds reversibly to pressure changes. This study provides initial insights toward the realization of a CO_2-based magnetic fluid, and further optimization of particle surface modification is expected to lead to the construction of a more stable CO_2-based magnetic fluid system.

Type:

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