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Transport and Detachment Characterization of Nanoparticle-Laden Oil Droplet in Pore-Throat Channel

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To enhance the applications of nanoparticles (NPs) in enhancing oil recovery, a crucial aspect is gaining a comprehensive understanding of the transport and detachment mechanisms of oil droplets through a pore throat. A novel, hybrid pore-scale simulation method is proposed, utilizing a combination of Lattice-Boltzmann (LB) and Langevin-Dynamics (LD) approaches to investigate the transport and detachment mechanisms of a nanoparticle-laden oil droplet. The LD method is specifically developed to capture the intricacies of Brownian motion, thermal fluctuation-dissipation, multi-body hydrodynamics, and particle-particle interactions. The discrete LB forcing source distribution is integrated with LD, enabling a comprehensive evaluation of random forces, friction forces, van der Waals forces, and electrostatic forces involved in the transport and detachment of nanoparticle-laden oil droplet in a narrow microchannel. The variation in pressure difference is observed when the oil droplet transport in a narrow channel. And the nanoparticle-laden oil droplet when transporting in the channel shows a less pressure difference compared with oil droplet without NPs adsorbed on. Moreover, with some NPs attached on the channel, there is little oil trapped on the channel. The oil droplet detaches from the channel with the help of NPs. Results demonstrate that oil droplet detachment from a surface is not related with surface wettability and the adsorbed area of NPs is critical in detachment process. The outcomes of this work provide valuable insight into the critical importance of nanoparticles effects on the detachment and transport of oil droplet in porous media.

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