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3D Hybrid Multiphysics Lattice Boltzmann Model for Studying the Flow Behavior of Emulsions in Structured Rectangular Microchannels

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Abstract : A three-dimensional (3D) hybrid quasi-steady thermal lattice Boltzmann model is developed to couple the effects of surfactant, temperature, interfacial tension, and contact angle. This 3D model is an extended scheme of a previously introduced two-dimensional (2D) hybrid lattice Boltzmann model. The 3D model is used to study the combined multi-physics effects on emulsion systems flowing in rectangular microchannels with and without confinements, where the suspended phase is made of droplets, plugs, or a mixture of both. The simulation results show that emulsion systems with plugs as the suspended phase are more efficient than with droplets, whereas mixed systems that form large plugs through coalescence have even greater efficiency. The 3D contact angle model generates matching results to those of the 2D model, which were validated with experiments. Furthermore, the effects of various confinements on adhering single drop systems are investigated for delineating their influence on the power required for transporting the suspended phase through the channel. It is shown that the deeper the constriction is, the lower the system efficiency. Increasing the surfactant concentration or fluid temperature in a channel with confinement carries a substantial positive effect on oil droplet transportation.

Keywords : lattice Boltzmann method, thermal, contact angle, surfactants, high viscosity ratio, porous media
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