SURFACTANT EFFECTS ON ONE OR TWO DEFORMABLE DROPS IN AXISYMMETRIC GRAVITATIONAL MOTION

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Surfactants are important in a wide variety of applications, in both traditional areas such as detergent and the processing of many materials and in growing research areas such as microfluidics, 'smart' drug delivery, and liquid crystals. Because surfactants are active at liquid-liquid interfaces, their action can be decisive in determining the end result of droplet interactions in an immiscible mixture, including coalescence, stability and breakup. The focus of this paper is to study how bulk insoluble nonionic surfactant affects one or two deformable drops in axisymmetric buoyancy-driven Stokes flow.

Recent three-dimensional calculations [1] indicate that for two surfactant-covered drops sedimenting under gravity, breakup of the larger drop can become dominant over that of the smaller drop, as measured by critical horizontal offsets. These results suggest the possibility of gravity-driven breakup of an isolated contaminated drop. Although previous study [2] has been made by perturbation analysis on the deformation of a single drop with surfactant at low Reynolds and capillary numbers, to our knowledge, it remains an open questions whether a single drop with a higher capillary number or Bond number at high interfacial tension gradients will deform significantly. In addition, we consider axisymmetric interactions of two deformable drops to obtain more accurate details of the surfactant profile in breakup and capture than the three-dimensional code will allow.

The simulations are based on the boundary-integral method formulated in axisymmetric coordinates for this problem [3]. A linear equation of state is used for the relationship between interfacial tension and the surfactant surface concentration. In solving the time-dependent convective-diffusion equation for the surfactant concentration, local paraboloid fitting is used to determine the surface gradients of the surfactant concentration and tangential velocity. The deformation of a single drop and trajectories for two drops are then found by simultaneous solution of the convective-diffusion equation together with the boundary-integral formulation for the velocity field.

References

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