SURFACTANT EFFECTS ON DROP DETACHMENT

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We study surfactant effects on the evolution of detaching drops numerically for the case of a viscous drop in a viscous fluid. Elongated drops detach by the rapid, surface tension driven pinching of a neck. In the absence of surfactants, surface contraction is fastest near the neck. Thus, when surfactants are present, they accumulate there and alter the ensuing dynamics by reducing the surface tension that drives the contraction.

In our simulations, the surface tension is described by a nonlinear surface equation of state that accounts for the maximum packing of surfactant in a monolayer. When surfactant adsorption-desorption is very slow, interfaces dilute significantly during drop expansion, and drops form necks that are only slightly perturbed in their dynamics from the surfactant-free case. When adsorption-desorption dynamics are comparable to the rate of expansion, the necks form slowly, with a variety of shapes, depending on the amount of surfactant present in solution. Significantly, they fail to neck at all at elevated coverages. When surfactant adsorption-desorption kinetics are rapid, the surface remains in equilibrium with the surrounding solution, and drops break like surfactant-free drops with a uniform surface tension.

These arguments are used to construct a phase diagram of drop neck shapes as a function of surfactant coverage. A map of neck/no-neck thresholds is also constructed as a function of surfactant coverage and sorption dynamics, suggesting that drop detachment can be used as a means of characterizing surfactant dynamics. The impact of these effects on satellite drop distribution is presented. Preliminary work in the limit where both bulk surfactant diffusion and surfactant adsorption-desorption play a role in determining the surface concentration will also be described.

Keywords: surfactant, drop, adsorption, surface tension, necking, Marangoni effects