HINDERED COALESCENCE IN THE PRESENCE OF INSOLUBE SURFACTANTS

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For moderate capillary numbers, i.e. Ca=O(0.05÷0.3), simulations and theory for two viscous drops undergoing a flow induced head-on collision in a viscous matrix in the Stoke flow limit showed that coalescence is hindered [1,2], i.e. the film reached a steady state thickness h_{SS}. We analyze this phenomenon in the presence of insoluble surfactants both for high (Γ=60% Γ_{max}, where Γ_{max} is the maximum surfactant concentration) and low (Γ=1.6% Γ_{max}) surfactant concentrations through the use of boundary integral calculations of the full drop problem [3]. The equation of state used is appropriate for high molecular weight surfactants, in the specific block copolymers in the dry-brush regime. As shown in figure 1, h_{ss} in the presence of surfactant is smaller than h_{ss} of a clean interface system and it decreases as the parameter γ (a material parameter inversely proportional to the surfactant surface diffusivity, such that $Pe_s=\gamma Ca$, where Pe_s is the surface Peclet number) increases. Contrary to intuition, h_{ss} decreases with increasing the surfactant concentration, i.e. high surfactant concentration systems are "less" stable against coalescence than low surfactant concentration systems, for the same γ. Moreover, for high Γ, as γ is increased, the film drains continuously with time. A comparison between surfactant covered drops and interface drops with different viscosity ratio is also presented. Drops with surfactants, even present in traces amounts, appear to behave like drops with very high viscosity ratio O(100), as shown in figure 2.

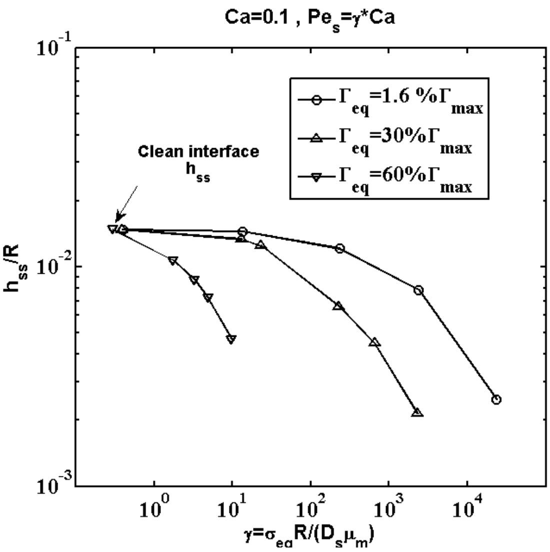

Figure 1. Steady state minimum film thickness h_{ss}/R as a function of the material property parameter γ, where Pe=γ*Ca, for Ca=0.1.

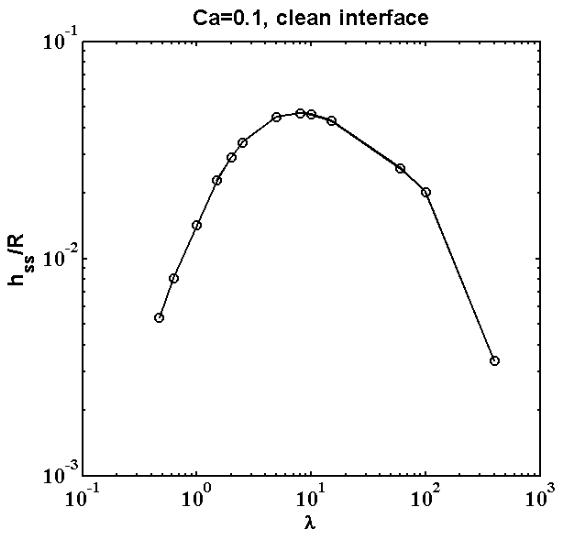

Figure 2. Effect of viscosity ratio λ on h_{ss}/R for a clean interface system and Ca=0.1.

[1] Nemer, M.B., Chen, X., Papadopoulos, D.H., Blawzdziewicz, J. and Loewenberg, M. Hindered and enhanced coalescence of drops in Stoke flow. Phys. Rev. Lett. 2004, 92.
[2]Yoon, Y., Baldessari, F., Ceniceros, H.D. and Leal, L.G. Coalescence of two equal-sized deformable drops in an axisymmetric flow. Phys. Fluids. 2007, 19.
[3] Dai, B. and Leal, L.G., The Mechanisms of surfactant effects in drop coalescence. Phys. Fluids. 2008, 20.