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Controllable internal mixing in coalescing droplets induced by the solutal Marangoni convection of surfactants with distinct headgroup architectures

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Abstract

Through several complementary experiments, an investigation of the bulk and interfacial flows that emerged during the coalescence of two water-in-oil droplets with asymmetric compositional properties was performed. By adding surfactant to one of the coalescing droplets and leaving the other surfactant-free, a strong interfacial tension gradient (i.e., solutal Marangoni) driving energy between the merging droplets generated pronounced internal mixing. The contributions of two distinct types of surfactant, anionic ammonium lauryl sulfate (ALS) and cationic cetyltrimethylammonium bromide (CTAB) on the rate of coalescence bridge expansion and on the generation of opposing flows during coalescence were investigated. All coalescence experiments supported the power law relation between the radius of the expanding connective liquid bridge and time, $r_b \propto t^{1/2}$. However, the presence of surfactant decreased the magnitude of the prefactor in this relationship due to induced interfacial solutal Marangoni convection. Experiments showed that packing efficiency, diffusivity, and bulk concentration of the selected surfactant are vital in solutal Marangoni convection and thus the degree and timescale of internal mixing between merging droplets, which has yet to be adequately discussed within the literature. Denser interfacial packing efficiency and lower diffusivity of CTAB produced stronger opposing

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