Gas accumulation at liquid-liquid interfaces

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Dissolved atmospheric gases are typically assumed to have negligible influence on liquid behaviour because their solubility is too low to affect macroscopic properties. However, long-standing observations contradict this view: for example, it is well known that dissolved gases can accumulate at solid hydrophobic surfaces immersed in water;[1] the emergence of long-range hydrophobic interactions has been ascribed to nanobubble cavitation between two hydrophobic surfaces;[2] as the concentration of dissolved gases in an oil-in-water emulsion decreases, the average time of droplet coalescence significantly increases.[3,4]

In this work, we developed a precise droplet rise experiment that explores the boundary conditions for flow at oil microdroplets as a function of the gas content.[5] By using high speed shadowgraphy, we measure a faster rise velocity for microdroplets of oil (silicone oil and hexadecane) released in quiescent gassed water, than expected based on a no-slip boundary condition. We fit the rise velocity with a slip length that increases from a few µm for partially gassed liquids, to tens of µm for fully gassed water. Interfacial gas enrichment governs these effects, in the form of gas layers forming at the liquid-liquid interface, of thickness up to several hundred nanometers. Negligible or negative slip was measured for contaminated systems, confirming that the liquid-liquid interface becomes immobilised when impurities are present.

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