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Marangoni Stresses and Volatility Effects on Bubble Rupture Dynamics

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Abstract

We investigate surface bubble lifetime and rupture dynamics in pure water, SDS solutions, and volatile decane using high-speed imaging. In water, evaporation-induced Marangoni stresses drive upward flow, consistently thinning the film at the foot and causing rupture at that location. SDS suppresses Marangoni effects by eliminating surface tension gradients, shifting drainage dominance to curvature-driven flow, and leading to apex rupture. In decane, volatility drives thermal Marangoni flows: cooling accelerates drainage via downward flow and causes rapid foot rupture, while heating reverses the gradient, thickens the cap, and extends bubble lifetimes beyond 12 minutes. Schlieren imaging visualizes the thermally induced flow. These results demonstrate how surfactants and thermal gradients enable precise control of bubble stability and rupture location, relevant to aerosol generation, interfacial transport, and gas exchange in environmental and industrial systems.

Keywords:

Cavitation Nucleation Collapse Coalescence