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Using time-dependent experiments and simulations to establish the role of surfactant in increasing drag over superhydrophobic surfaces
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Superhydrophobic surfaces (SHS) can potentially achieve drag reduction for both internal and external flow applications. However, experiments have provided inconsistent results, with many studies reporting significantly decreased performance. While a complete explanation is yet to be found, it has been proposed that surfactants, ubiquitous in flow applications, could be responsible, as Marangoni stresses could develop when the edges of the SHS are not aligned with the flow. However, testing this hypothesis has been challenging. Even careful experiments with purified water have shown large interfacial stresses; adding surfactant yields only small drag increases, potentially revealing a pre-existing contamination of the interface. Other common physical processes, such as thermal Marangoni stresses and interface deflection, could also explain the lower performance. We address this question with numerical simulations, including surfactant kinetics, and SHS experiments in a micro-channel, where we control temperature gradients and interface deflections. By imposing a time-dependent pressure gradient, we are able to drive complex interface dynamics that can only be explained by surfactant gradients. Our results demonstrate the role of surfactants in increasing drag over superhydrophobic surfaces.

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