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Superhydrophobic Drag Reduction: From Droplet Movement to Boundary Layer Flows

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Abstract

Micro- or nano-patterned hydrophobic (so-called superhydrophobic) surfaces have attracted much interest for the application to hydrodynamic friction reduction for both droplet movement and continuous flow. In droplet movement, the friction is mainly determined by the pinning of a contact line, affected by various surface parameters including chemical heterogeneity, physical structures, and interfacial wetting states. The influence of surface structures on the droplet pinning has been studied from the perspective of both kinetics and dynamics. However, the results are not consistent and the critical factors that determine the pinning mechanics have not been clearly understood. Moreover, the direct mechanism of how the surface structures regulate the depinning dynamics of a moving droplet on superhydrophobic surfaces has not been revealed much. In the first half of this talk, our recent study on the pinning/depinning mechanism of a moving droplet on superhydrophobic surfaces will be presented to propose new physical criteria and design rules to determine the retention force of a droplet moving on a superhydrophobic surface. In the case of viscous flow, the hydrodynamic friction reduction on a superhydrophobic surface is achieved by the gas layer or bubbles retained on the surface, taking advantage of the sizable difference in their viscosities. The frictional drag reduction on superhydrophobic surfaces in laminar flow has relatively been well understood from both experimental and theoretical studies. However, that in turbulent flow has not yet been clearly understood. In the second half of this talk, our recent study and understanding on the frictional drag reduction on superhydrophobic surfaces will be presented, including both laminar and turbulent flows.