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Easy-to-use correlations to estimate droplet mobility on hydrophobic fibrous coatings

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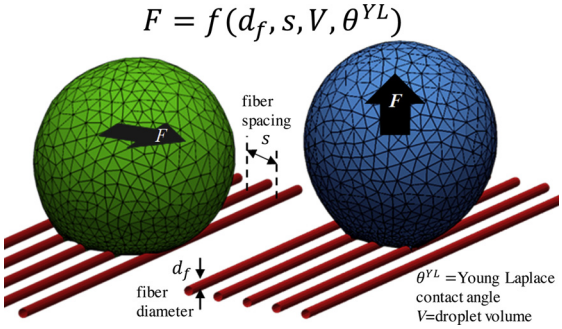
GRAPHICAL ABSTRACT



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ABSTRACT

While a water droplet beads up on a hydrophobic fibrous surface, it does not necessarily detach or move on the surface under its own weight. The underlying physics of droplet adhesion to a rough surface is very complicated, and the ability to engineer a fibrous texture that promotes or prevents droplet mobility for droplets of different liquids has been a long-standing challenge. In this concern, the current work is devised to develop easy-to-use correlations for the force needed to detach a droplet from a hydrophobic fibrous coating in the in-plane and out-of-plane directions. These correlations are obtained by first writing an equation for the balance of forces acting on a detaching droplet in terms of its geometrical dimensions at the moment of detachment, and then relating these dimensions to those in the absence of an external force via curve fitting to a series of computational data. These easy-to-use correlations only require the physical properties of the fibrous coatings (e.g., fiber diameter, fiber spacing, and fiber contact angle) and the droplets (e.g., volume and surface tension) as inputs, and they can therefore be used to optimize the surface geometry prior to manufacturing. To examine their accuracy, predictions of these correlations are compared to experimental data obtained for droplet detachment from fibrous mats with fibers having a diameter of about two orders of magnitude smaller than those considered in developing the correlations.

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