Competing forces on a liquid bridge between parallel and orthogonal dissimilar fibers†

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This paper presents a detailed investigation on the mechanical forces acting on a liquid bridge between dissimilar fibers in parallel and orthogonal configurations. These forces were measured experimentally, using a sensitive scale, and were also predicted computationally, via numerical simulation. Special attention was paid to the fiber–fiber spacing at which the liquid bridge detached from the fibers, and to how a transition from an equilibrium liquid bridge to a spontaneously (time-dependent) detaching bridge took place. It was found that, while varying the spacing between the fibers affects a liquid bridge differently for fibers with different relative angles with respect to one another, the spacing at which the bridge detaches from the fibers is independent of the fibers’ relative angle. This paper also formulates the contribution of the geometrical and wetting properties of the fibers competing for the droplet that results from a liquid bridge detachment, and presents a mathematical expression to predict the fate of that droplet.

1 Introduction

A liquid bridge between two solid surfaces has been the focus of many previous studies due to its ubiquitous presence in a variety of applications. The capillary force generated by a capillary bridge contributes to the adhesion force that frogs, insects, or geckoes create to climb a vertical surface. 1, 2 For instance, a particular type of beetle can generate an adhesion force of more than 60 times its body weight thanks to an array derived the Young-Laplace equation, which predicts the equilibrium from a liquid bridge to a spontaneously (time-dependent) detaching bridge took place. It was found that, while varying the spacing between the fibers affects a liquid bridge differently for fibers with different relative angles with respect to one another, the spacing at which the bridge detaches from the fibers is independent of the fibers’ relative angle. This paper also formulates the contribution of the geometrical and wetting properties of the fibers competing for the droplet that results from a liquid bridge detachment, and presents a mathematical expression to predict the fate of that droplet.

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