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On liquid bridge adhesion to fibrous surfaces under normal and shear forces

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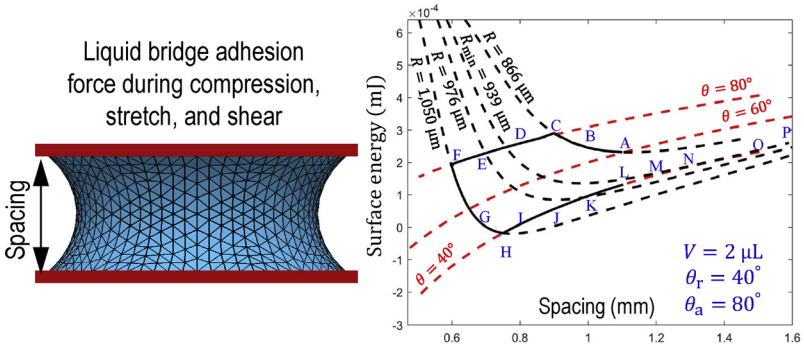
GRAPHICAL ABSTRACT



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ABSTRACT

This paper reports on adhesion forces between a liquid bridge and two parallel plates coated with electrospun fibers experimentally and computationally. For the experiments, a DI water droplet containing 15% glycerol was placed on one of the plates and compressed, stretched, or sheared using the other plate. The assembly was mounted on a sensitive scale to measure the forces applied to the plates during the experiment. For the computational part, an efficient modeling approach was developed to predict the 3-D shape of the liquid bridge and to calculate its resistance to normal and tangential forces in the presence of contact angle hysteresis effects, using the Surface Evolver finite element code.

Despite the inherent non-uniformity of the fibrous surfaces used in the experiments and the simplifying assumptions considered for the simulations, reasonable agreement was observed between the measurements and their computational counterparts. In addition, the hysteresis behavior of a liquid bridge during a compression–stretching process is mapped in an energy or force diagram versus spacing between the plates using radius-constant and contact-angle-constant lines describing the triple contact-line. It was also observed that a liquid bridge between two electrospun coatings tends to maintain its symmetricity despite the anisotropic roughness of the coatings, due perhaps to the minuteness of the electrospun fibers relative to the size of the liquid bridge.

1. ıntroduction

Formation of a liquid column between two surfaces is often referred to as a liquid bridge. Liquid bridges are seen in nature, e.g., in frogs, insects, or geckoes climbing a wall [1–3] or in wet beach sands adhering to one another [4], and in industrial applications like printing [5,6], microstereolithography [7,8], papermaking [9], filtration [10], or atomic force microscopy [11,12]. Pioneering research on liquid

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