Droplet at the corner of a V-shaped fibre

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Droplet-fibre interactions, such as droplets on horizontal, bent, and patterned fibres, have attracted significant research interest due to their wide engineering applications. However, the behavior of droplets, particularly the maximum droplet volume that can be suspended, at the vertex of a V-shaped fibre (see Fig. 1(a)), remains unexplored. Motivated by this gap, we investigate the capacity of a V-shaped fibre in retaining droplets at its corner.

We designed an experimental setup that enables precise adjustment of the crossing angle (2θ, and see Fig. 1(b)) between two cylindrical fibres. Experiments are conducted by delivering liquid to the vertex of the V-shaped fibre using a syringe pump. A droplet is formed at the V-corner, and its volume gradually increases until it falls, at which point the maximum volume is determined based on the pumping duration. The shape of the droplet before dropping off is recorded using a high-speed camera. Various combinations of liquids and fibres with different diameters are tested.

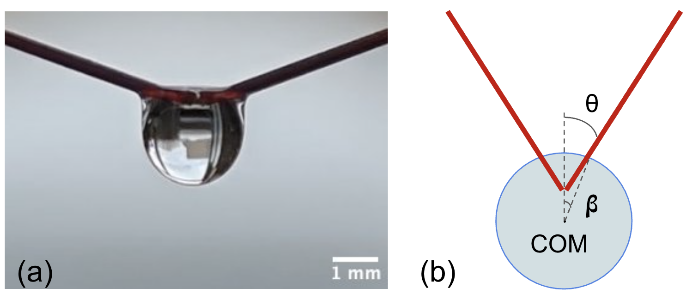

Figure 1: Droplet at the corner of V-shaped fibre, a) Experiment image and b) Schematics.

Using a free-energy approach, we developed an analytical model for the maximum droplet volume (Ω_*) at the corner of a V-shaped fibre, as a function of θ. Unlike existing models predicting the maximum droplets hanging on fibres, our model accounts for the variation of liquid-air interfacial energy. Particularly, for the droplet at the vertex of the V-shaped fibres, the movement of three-phase contact lines is associated with the non-negligible change of liquid-air interfacial area, and is critical to the stability of the droplet. Our model is validated against experimental data.

Interestingly, we find that the maximum droplet volume (Ω_*) does not vary monotonically with the crossing angle (θ). Instead, it is closely related to an off-axis angle (β, the angle between the vertical and the line connecting the droplet's center of mass (COM) to the three-phase contact point where the fibre exits the droplet, see also Fig. 1(b)).

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