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Evaporating drops on fiber: how the fiber influences their lifetime?

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Evaporation is ubiquitous in natural phenomena such as sea spray dynamics or animals perspiration. This phase transition also plays a major role in many industrial processes like coating, spray cooling or powder production. Moreover, understanding the drying of facial mask could provide new insights into limiting the spread of Covid-19. The evaporation dynamics depends strongly of the geometry of the liquid, which is related to its surface tension and the substrate wetting properties and also to the substrate thermal properties [1]. While evaporation of spherical and sessile droplets have been widely investigated for the last century, studies of evaporation in other geometries remain scarce.

Here we investigate experimentally the evaporation of a drop deposited on a fiber. Our measurements reveal that the fiber can have a significant effect on the drop lifetime depending on both the nature of the liquid and the fiber material. We attribute this difference to the thermal properties of the substrate (Fig. 1). We propose an analytical model to predict this lifetime for diffusion-limited and forced-convective evaporation by taking into account evaporation cooling effects and thermal conductivity of the fiber. This model provides a dimensionless parameter to evaluate the significance of the substrate conductivity on the drop lifetime. Our model is validated by comparison to our experiments for which the liquid and the fiber material are systematically varied.

[1] Stauber, Wilson, Duffy, Sefiane, Journal of Fluid Mechanics, 2014, 744, R2.
[2] Boulogne, Sauret, Soh, Dressaire, Stone, Langmuir, 2015, 31, 10, 30943100.

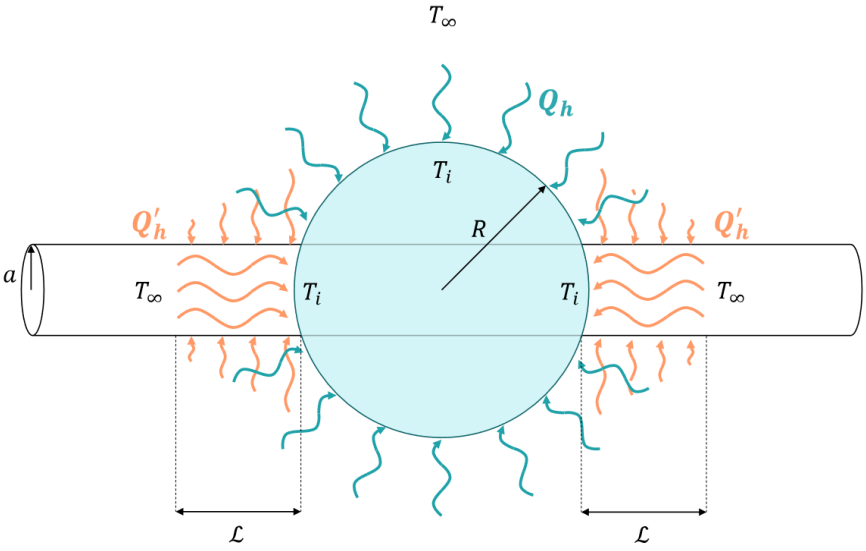

Figure 1: Schematic representation of a droplet deposited on a fiber and of the thermal fluxes exchanged between air, liquid and solid during the droplet evaporation