Drop impacting a thin fiber

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Fiber filters are extensively used to recover the liquid phase from polluting aerosols or from fogs in deserted areas. These filters consist of networks of randomly oriented fibers that capture the liquid phase while the gaseous phase passes through it. Their aims are twofold: first to capture the largest amount of liquid then to slow down the remaining fragment. Their optimizations – of obvious practical interest – are difficult tasks since the filtration processes depend on a wide range of parameters: macroscopic parameters such as the density of fiber and of droplets within the aerosol and microscopic parameters that characterize the impact of a single drop on a fiber.

Thus, to quantify the ability of a single fiber to retain a fraction of the liquid drop, we focus on the impact process and experimentally study the impact of a single drop on a fiber. We especially stress on two points. First, we emphasize on the impact velocity V and show that the drop can be entirely captured by the solid fiber below a critical velocity of impact V_c. We discuss the possible forces able to slow down the drop during the impact, and stress in particular the role of capillarity. The complex geometry of the problem – constrained by both the spherical symmetry of the drop and the axial symmetry of the fiber - makes the determination of the dynamic capillary forces not straightforward. We evaluate them by considering the static situation of the heaviest drop which can be hung by horizontal fiber. A dynamic model is eventually proposed for the critical velocity of capture.

Then, we focus on the influence of the relative position of the drop and the fiber. For drops impacting below the critical velocity of impact, the fiber captures the whole volume of the drop if the impact is centered (when the trajectory of the drop and the axis of the fiber intercept). However, for drops impacting above the critical velocity of impact, we observe that the fiber retains the largest portion of the liquid drop when the axis of the fiber and the trajectory of the drop do not intercept, hence if the impact is off-centered. We propose a model to explain those results.