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Capillary Rise Dynamics of Well-Wetting Liquids on the Outer Surfaces of Cylindrical Nozzles in Low Flow Rate Limits ERFAN SEDIGHI, NAVID DEHDARI EBRAHIMI, Y. SUNGTAEK JU, Mechanical and Aerospace Engineering Department, University of California, Los Angeles, MTSLAB TEAM —
Parts of well-wetting liquids exiting small-diameter nozzles at low flow rates can rise up along the outer nozzle surfaces. This is problematic for fuel injectors and other devices that incorporate arrays of nozzles to distribute liquids. We will report our experimental and numerical study of this phenomenon for wide ranges of parameters, including the nozzle outer diameter (0.2 to 3.2 mm), flow rate (0.1 to 300 μL/s), viscosity (1.75 to 970 mPa s), and surface tension (18.7 to 45 mN/m). Our study showed that the interplay of three dimensionless numbers (the Bond number, the Weber number, and the Ohnesorge number) governs the capillary rise dynamics. In general, as the flow rate increases, the capillary rise height at each normalized time becomes smaller. We identified limiting liquid flow rates below which the temporal evolution of the meniscus positions can be well approximated by a quasi-static model based on the Young-Laplace equation. The nozzle diameter and the contact angle at the nozzle surface primarily determine the maximum meniscus height for a particular liquid in the limit of near zero flow rates. For a given contact angle, the capillary rise ceases to occur above a predictable threshold Bond number.

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