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Experimental Research on Neck Thinning Dynamics of Droplets in Cross Junction Microchannels

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Abstract : Microscale droplets play an increasingly important role in various applications, including medical diagnostics, material synthesis, chemical engineering, and cell research due to features of high surface-to-volume ratio and tiny scale, which can significantly improve reaction rates, enhance heat transfer efficiency, enable high-throughput parallel studies as well as reduce reagent usage. As a mature technique to manipulate small amounts of liquids, droplet microfluidics could achieve the precise control of droplet parameters such as size, uniformity, structure, and thus has been widely adopted in the engineering and scientific research of multiple fields. Necking processes of the droplet in the cross junction microchannels are experimentally and theoretically investigated and dynamic mechanisms of the neck thinning in two different regimes are revealed. According to evolutions of the minimum neck width and the thinning rate, the necking process is further divided into different stages and the main driving force during each stage is confirmed. Effects of the flow rates and the cross-sectional aspect ratio on the necking process as well as the neck profile at different stages are provided in detail. The distinct features of the two regimes in the squeezing stage are well captured by the theoretical estimations of the effective flow rate and the variations of the actual flow rates in different channels are reasonably reflected by the channel width ratio. In the collapsing stage, the quantitative relation between the minimum neck width and the remaining time is constructed to identify the physical mechanism.

Keywords : cross junction, neck thinning, force analysis, inertial mechanism
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