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A computational study of drop formation in microfluidic devices

CHUNFENG ZHOU, PENGTAO YUE, JAMES J. FENG, University of British Columbia — Capillarity has a prominent role in flow in microfluidic devices because of the typically small linear dimensions, large curvature and large surface area in these geometries. Applications of micro-drops and micro-bubbles in small channels range from micro-pumps to ultrasound contrast agents [1]. In this study, we concentrate on the process of drop formation in microdevices, which has been used for generating uniform emulsions of Newtonian and non-Newtonian fluids, with an emphasis on the effects of fluid rheology. The bulk rheology and interfacial motion are described in a phase-field framework [2], and the numerical solution uses a finite-element algorithm with adpative meshing to ensure proper resolution of the interfaces. We will present simulations of drop formation at the tip of a jet either within a quiescent medium or inside a flow-focusing device as demonstrated in recent experiments [1,3]. The rheology of the components may be Newtonian, viscoelastic or liquid-crystalline, with the Oldroyd-B and Leslie-Ericksen models being used for the latter. Results show that component rheology is a major determinant in the morphology of the jet, the details of the breakup process, and the size distribution of drops. The solutions compare favorably with experiments.

1. H.A. Stone etc, Ann. Rev. Fluid Mech. 36, p.381(2004).
2. P. Yue etc, J. Fluid Mech. 515, p.293 (2004).
3. B. Steinhaus etc, Bulletin APS, 49, No. 9, p. 67 (2004).

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