Computational flow modeling of multiphase flow in microfluidic devices and capillaries

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Microfluidics refers to a set of technologies that control the flow of small quantities of fluids, usually in the order of nano or pico liters. From mature technologies, such as inkjet printing, lab-on-a-chip, to fledgling ones such as combinatorial drug discovery, μ-TAS (miniaturized total chemical systems), to conceptual ones such as micro-reactors, microfluidic devices abound with engineering challenges related to fluid-mechanics in the sub-millimeter length scales.

In electronic and chemical engineering applications miniaturization of large scale processes requires a better understanding of the process and issues involved with scaling-down devices. Factors such as the need for rapid response on frequent start-up and shut-down, excessive pressure drop, better mixing may further complicate scaling down of these systems. Another area of great interest in microfluidic systems is to understand their applications in design of micro-reactors which are showing future promise in applications in chemical and biomedical and life sciences. Microfluidic devices offer great advantages such as small volumes, readily automated, portable, and parallelizable. Yet they also provide challenges in understanding their performance in mixing, dispersion and cost of manufacturing. The design concerns in these devices can be as straight forward as understanding flow and species transport to modeling droplet break up and reaction.

In this study, the critical issues of fluid mechanics such as species transport (mixing, dispersions etc), multiphase flow of droplets and bubbles are studied, and the applicability of Computational Fluid Dynamics (CFD) techniques as applied to flow problems in the sub-millimeter range is evaluated. The focus is specifically at two fluid systems fist in T-junction where one can study the effect of aspect ratio, flow rate, and systematic generation of droplets. The study is then extended to look at application of CFD is used flow transport in capillary flows.