CONTROL OF DROPLET BREAKUP AND COALESCENCE AT MICROFLUIDIC JUNCTIONS

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Droplet-based microfluidic devices offer possible advantages for lab-on-a-chip applications due to minimized dispersion and sample loss, and the ability to control sample volume and surface chemistry [1,2]. In order to fully utilize such devices it is often necessary to control the breakup and coalescence of droplets within microchannels. Previous work has shown that droplets formed can adopt a range of shapes, from spherical to plug-like, depending upon their relative size compared with the microchannel cross-section [3,4]. This relative confinement of droplets within a microdevice influences the ability to further break a given drop, or to enable a drop to merge with other drops. The ability to tune the droplet volume and to merge droplets with potentially different contents will enable the development of future droplet-based lab-on-chip devices in which the droplets can be used as precise nanoreactors.

In this paper we present observations and modeling of droplet breakup and coalescence at various microfluidic junctions. Droplets are initially formed at a T-shaped junction. We present a lubrication model that captures the effect of external and internal phase liquid flow rates, channel geometry, and downstream pressure drop on the resulting droplet size and frequency. Downstream, droplets are further broken at a second junction, similar to that previously reported by Link et al [5]. The presence of a flexible valve in one arm of the junction allows precise, *on-demand* control of the droplet geometry by varying the relative resistance of the arms in line. Finally, further downstream, droplets of different volumes and different internal contents are merged at a third junction. Here, we observe that coalescence of large, plug-like droplets is difficult and that, in fact, droplets can collide and bisect each other, leading to further breakup rather than coalescence. We present observations of breakup and coalescence at these junctions as a function of initial droplet size, shape, and velocity.

References

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