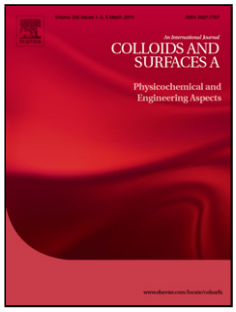

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Flow Regime Mapping of Aqueous Two-Phase System Droplets in Flow-Focusing Geometries

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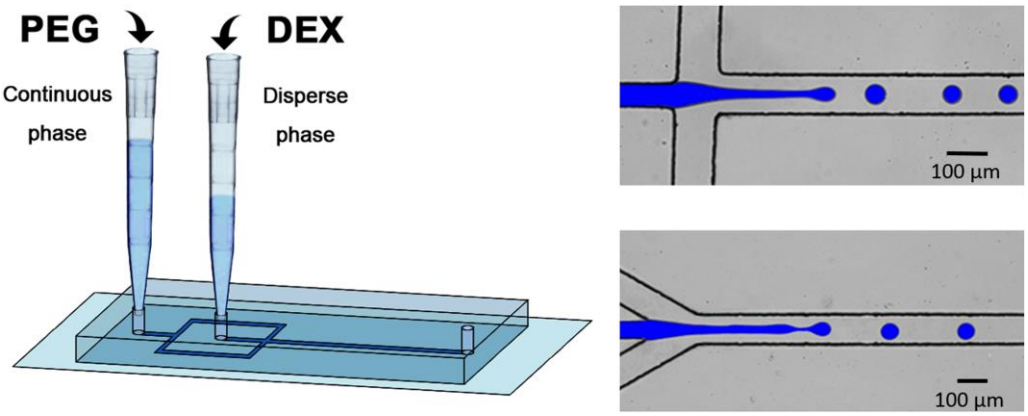
Graphical abstract



ABSTRACT

The recent advent of aqueous two-phase system (ATPS) has shown great potential to rapidly generate microscale aqueous droplets without tedious post-processing. ATPS provides a more biologically friendly and straightforward method to manufacture aqueous droplets compared with conventional oil-water systems and as such, it has been employed in many biomedical applications. Although the cost-effective manufacturing of aqueous droplets has been feasible by direct generation in ATPS, an understanding of the underlying physics of droplet formation in ATPS is still in its infancy. In this paper, we investigated the hydrodynamic behavior and mechanisms of all-aqueous droplet formation in two flow-focusing droplet generators. This study specifically tests whether ATPS in different geometries generates aqueous droplets with different sizes and properties. To achieve these goals, two incompatible polymers, namely polyethylene glycol (PEG) and dextran (DEX), were mixed in water to make ATPS. The influences of inlet pressures and flow-focusing configurations on droplet size, droplet generation frequency, and thread breakup length were quantified. In addition, flow regime mapping for the two different droplet generators at 30° and 90° junction angles was obtained. The results show that droplet size is very susceptible to the junction angle. On the other hand, inlet pressures of the PEG and DEX flows readily control five main flow regimes including PEG Back Flow, DEX Back Flow, Dripping Flow, Jetting Flow and Stratified Flow. It is observed that generated droplets in the Jetting Flow regime are larger in the case of 30°, whereas larger droplets are obtained in the Dripping Flow regime at 90° configuration. The frequency of droplet generation increases and decreases by increasing P_{PEG} and P_{DEX},