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Micro-Droplet Formation in a Microchannel under the Effect of an Electric Field: Experiment

Authors : Sercan Altundemir, Pinar Eribol, A. Kerem Uguz

Abstract : Microfluidics systems allow many-large scale laboratory applications to be miniaturized on a single device in order to reduce cost and advance fluid control. Moreover, such systems enable to generate and control droplets which have a significant role on improved analysis for many chemical and biological applications. For example, they can be employed as the model for cells in microfluidic systems. In this work, the interfacial instability of two immiscible Newtonian liquids flowing in a microchannel is investigated. When two immiscible liquids are in laminar regime, a flat interface is formed between them. If a direct current electric field is applied, the interface may deform, i.e. may become unstable and it may be ruptured and form micro-droplets. First, the effect of thickness ratio, total flow rate, viscosity ratio of the silicone oil and ethylene glycol liquid couple on the critical voltage at which the interface starts to destabilize is investigated. Then the droplet sizes are measured under the effect of these parameters at various voltages. Moreover, the effect of total flow rate on the time elapsed for the interface to be ruptured to form droplets by hitting the wall of the channel is analyzed. It is observed that an increase in the viscosity or the thickness ratio of the silicone oil to the ethylene glycol has a stabilizing effect, i.e. a higher voltage is needed while the total flow rate has no effect on it. However, it is observed that an increase in the total flow rate results in shortening of the elapsed time for the interface to hit the wall. Moreover, the droplet size decreases down to 0.1 μL with an increase in the applied voltage, the viscosity ratio or the total flow rate or a decrease in the thickness ratio. In addition to these observations, two empirical models for determining the critical electric number, i.e., the dimensionless voltage and the droplet size and another model which is a combination of both models, for determining the droplet size at the critical voltage are established.

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