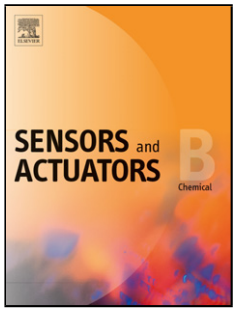

Title: Electric-Field Triggered, On-Demand Formation of Sub-Femtoliter Droplets

Authors: I-Ming Chen, Hsin-Hsien Tsai, Che-Wei Chang, Gaofeng Zheng, Yu-Chuan Su

PII: S0925-4005(17)32485-1
DOI: https://doi.org/10.1016/j.snb.2017.12.152
Reference: SNB 23840

To appear in: *Sensors and Actuators B*

Received date: 16-5-2017
Revised date: 29-11-2017
Accepted date: 23-12-2017

Please cite this article as: I-Ming Chen, Hsin-Hsien Tsai, Che-Wei Chang, Gaofeng Zheng, Yu-Chuan Su, Electric-Field Triggered, On-Demand Formation of Sub-Femtoliter Droplets, Sensors and Actuators B: Chemical https://doi.org/10.1016/j.snb.2017.12.152

Electric-Field Triggered, On-Demand Formation of Sub-Femtoliter Droplets

I-Ming Chen[1], Hsin-Hsien Tsai[1], Che-Wei Chang[1], Gaofeng Zheng[2], and Yu-Chuan Su[1]

[1]Department of Engineering and System Science, National Tsing Hua University, Taiwan
[2]Department of Instrumental and Electrical Engineering, Xiamen University, China

Email: ycsu@ess.nthu.edu.tw, Phone: 886-3-5742374, Fax: 886-3-5720724

ABSTRACT

This paper presents an electrohydrodynamic emulsification scheme that is capable of producing sub-femtoliter aqueous droplets on demand. A pressure-controlled flow focusing scheme is enhanced by integrating a time-varying electric field, which induces electric forces locally on the water-oil interface. More specifically, electric forces act against interfacial tension and trigger the breakup of droplets via tip streaming. PDMS microfluidic chips with embedded solid electrodes and diaphragm valves are utilized to realize the proposed on-demand droplet formation scheme. In the prototype demonstration, a low melting-point alloy mixed with magnetic nanoparticles was inductively heated and injected into microchannels to form solid electrodes. It is demonstrated that the emulsification process is controlled by the applied fluid pressures and electric field, but not limited by the minimum width of flow channel. Extremely small droplets with volumes less than 1 femtoliter can be readily produced. By applying a voltage ramp of 8 kV/s (0 to 400 volts in 50 ms) across a distance of 6 mm, droplets with diameters less than 1 μm were successfully produced. The higher the voltage ramp rate, the smaller the resulting droplet volume. By adjusting the voltage ramp rate accordingly, on-demand formation of a droplet stream with preset diameter order was demonstrated. As such, the demonstrated emulsification scheme could potentially realize the controllability of electric field on the on-demand formation of extremely-small droplets, which is desired for a variety of applications.