Electronic Supplementary Material (ESI) for Lab on a Chip

Electronic Supplementary Information (ESI) for:

Electrostatic charging and control of droplets in microfluidic devices

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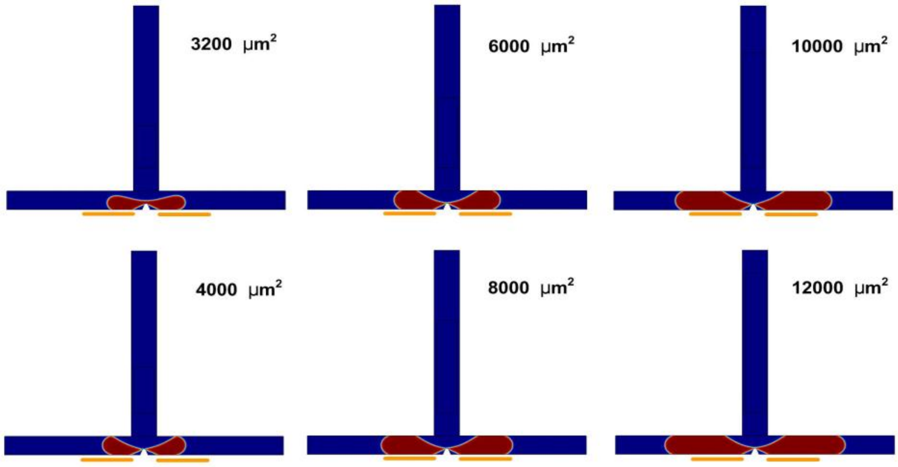
1. Simulation studies on droplets of different size

Numerical simulations were performed to study the droplet size effect on the whole system capacitance. The same simulation model (as described in 'Numerical Simulation') was adopted and the geometry was set according to fabricated devices (as shown in Fig.3), while the droplet size was changed. The results were shown in Fig. S1.



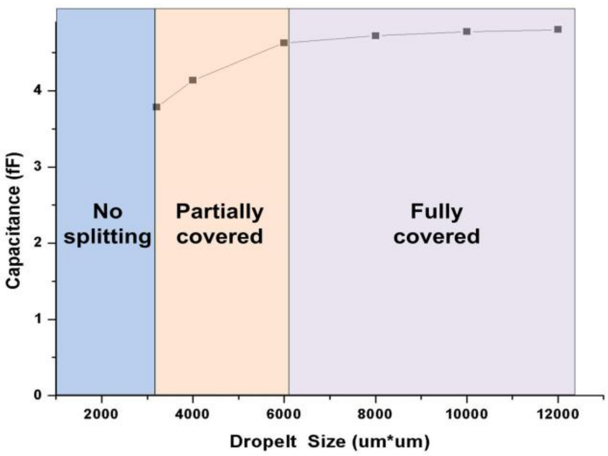


Fig. S1 Simulation results showing the droplet size effect on the system capacitance at the instant of separation. For 'No splitting' region, data of the system capacitance at the separation instant is not available since no separation occurs.

There are three regions as the droplet size increases (from 3200 to 12000 μm^2): (1) When the projected area of the droplet is smaller than 3200 μm^2, the droplet can not split at the T-junction. Negative and positive charges can not be ultimately separated into two daughter droplets and no charges will be obtained in droplets. (2) When droplet area is 3200-6000 μm^2, the droplet can split and partially covers the charging electrodes at the T-junction. In this region, more space across the charging electrodes is covered by water as the droplet size increases, and therefore the whole system capacitance is continuously increasing. (3) When the droplet area is greater than 6000 μm^2, the droplet fully covers the charging electrodes. Then the whole system capacitance gradually approaches a constant value. In summary, the size of the droplet can affect the whole system capacitance and then the ultimate charges in the daughter droplets. For a droplet of specific size, the system capacitance and corresponding induced charge can be obtained from the simulation model.

2. Simulation studies on use of surfactant

Use of surfactant could low the interface tension and help stabilize the droplets in microfluidics. Numerical simulations were performed to study the surfactant effect on the whole system capacitance. The same simulation model (as described in 'Numerical Simulation') was adopted. A T-junction without a notch (as shown in Fig. 2a) was used for observing the long and slim liquid thread. The interfacial tension was set from 0.005 N/m[1] to 0.038 N/m (for our mineral oil/water system). The simulation results are shown in Fig. S2.

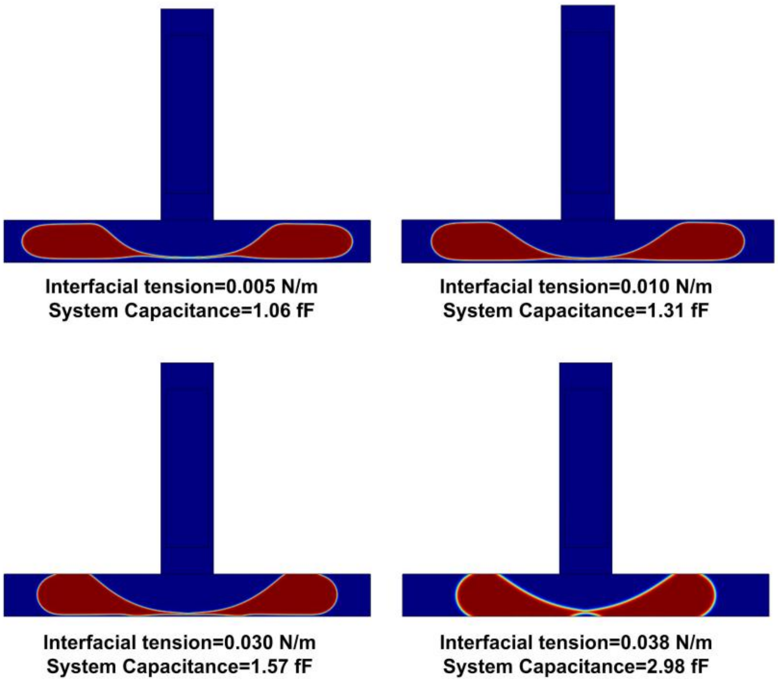


Fig. S2 Simulation results showing the surfactant effect on the droplet elongation and splitting at the separation instant.

When the interfacial tension decreases from 0.038 N/m to 0.005 N/m, the liquid thread becomes thinner and longer, which severely decreases the system capacitance from 2.98 fF to 1.06 fF at the separation instant.

Reference

1. M. Hashimoto, P. Garstecki, H. A. Stone and G. M. Whitesides, *Soft Matter*, 2008, **4**, 1403-1413.