Supplementary Material (ESI) for Lab on a Chip

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Supplementary information

S1 *Fabrication of the microfluidic platform and the detail dimensions/positions of the electrodes for droplet trapping, fusion and release*

Soft lithographic technique was employed to fabricate the microfluidic structure with poly(dimenthylsiloxane) (PDMS) as building blocks[28]. To make an array of electrodes, patterned Au film was used and electrodes were obtained by applying a standard lift-off microfabrication process on glass substrate with a Cr layer as an adhesion layer. Microfluidic platform was then formed by aligned bonding of the PDMS slip with the Au patterned glass with aid of oxygen plasma pretreatment. The Au electrode embedded in the microwell is located with its top edge of 100 μm away from the center of the microwell. The opposite electrode has a rectangular shape (width = 2000 μm) with its lower edge of 840 μm away from the center line of the main channel. The bottom right electrode as in Figure 1a is 800 μm in width and 685 μm and 900 μm away from the center of microwell.

S2 Off-line verification of the presence of Coulomb force on droplet contacted electrodes

Droplets contacted electrodes will obtain certain amount of charges and then are subjected to Coulomb force in the presence of electric field. This is verified by micropipetting a water droplet of around 200 μm in diameter into silicon oil in between two flat stainless-steel electrodes and then applying a 1000 V DC voltage across the two electrodes. The two stainless-steel electrodes have 30 mm, 15 mm and 2 mm in length, width and thickness

respectively.

S3 Detection of mercury ions in water through an droplet reaction array with both control and test reactions presented

For the detection of mercury ions, the probe solution (0.6 nM RB-AuNP-PDCA) is prepared according to the protocol reported by reference.[29] For test 1 and 2 shown in Figure 5, a droplet (300 μm in diameter) carrying the probe solution is fused with a droplet (300 μm in diameter) carrying 100 μM mercury ions followed by incubation for 10 minutes. For the control test shown in Figure 5, two probe droplets (300 μm in diameter) are coalesced and trapped in a microwell.

S3 Verification of contamination issue on electrodes

The mercury ion detection experiments were also used to verify if there is any contamination issue on the electrodes since the droplets may contact the electrode surface. After having carried out ten times repeated ion detection experiments as described earlier, we obtained the fluorescent images of all electrodes and checked these images under a fluorescent microscope. It was noted that there was no obvious fluorescence from all electrodes and there was no much difference between the electrodes in the control microwell and those in the test microwell. This can be understood that the presence of surfactants causes the stable thin oil film between the droplets and the electrode surface and thus prevents the direct contact of electrodes by the trapped droplets and eliminates the concern of electrode contamination.

Reference

[1] McDonald, J. C.; Duffy, D. C.; Anderson, J. R.; Chiu, D. T.; Wu, H. K.; Schueller, O. J. A.; Whitesides, G. M. *Electrophoresis* **2000**, *21*, 27-40.

[2] C. C. Huang, H. T. Chang, *Anal. Chem.* **2006**, *78*, 8332.