Supplementary Information

A centrifugal microfluidic pressure regulator scheme for continuous concentration control in droplet-based microreactors

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Structure design compatible with light oil and heavy oil

In order to expand the application areas, we designed structures compatible with both light oil and heavy oil respectively. In Figure S 1 (a), the density of dispersed phase is larger than that of the continuous phase. The fused droplets are transported towards the bottom of the collection chamber. In Figure S 1 (b), the density of dispersed phase is smaller than that of the continuous phase. The fused droplets are transported towards the top of the collection chamber.

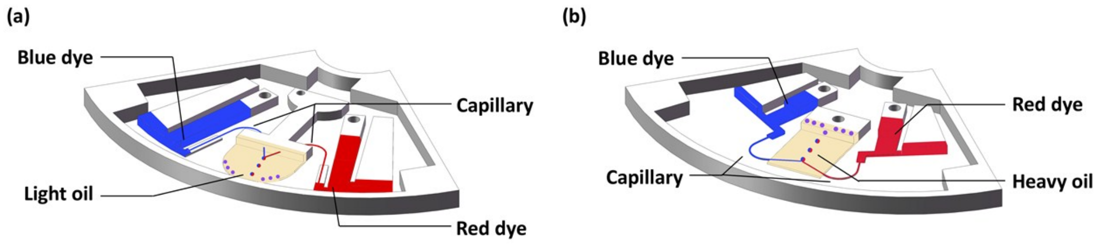

Figure S 1 Droplet fusion chip designs for different types of continuous phase (a) Light oil (b)Heavy oil

Calculation of coefficient of variation (CV)

During the experiment, we use a camera along with a synchronized stroboscope to record fluid motion on disc (Figure S 2 (a)). Also, in order to measure the size and coefficient of variation of droplets, we put the disc under a microscope after the experiment to observe the droplets more clearly.

We measured the diameter of 100 droplets using ImageJ software. Though it is difficult to measure the absolute size of each droplet, it is possible to calculate the CV of droplets since only the relative droplet size matters here[1]. Figure S 2 (b) shows that the 100 droplets have an average diameter of 360 µm with a CV of 1.1%.

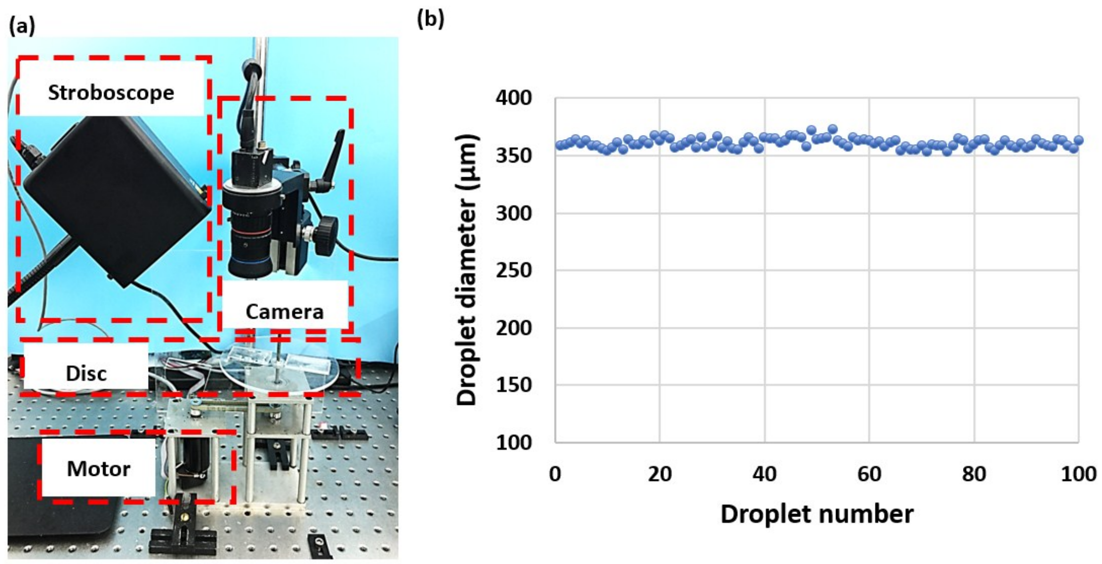

Figure S 2 a) Experimental set-up of the lab-on-a-disc platform. b) Diameter of 100 droplets measured using ImageJ software.

Calibration plot of the B value with respect to the blue dye concentration

Before the experiment, a calibration plot of the B value of the dye solution with different blue dye concentration was drawn. The B values were obtained using ImageJ software.

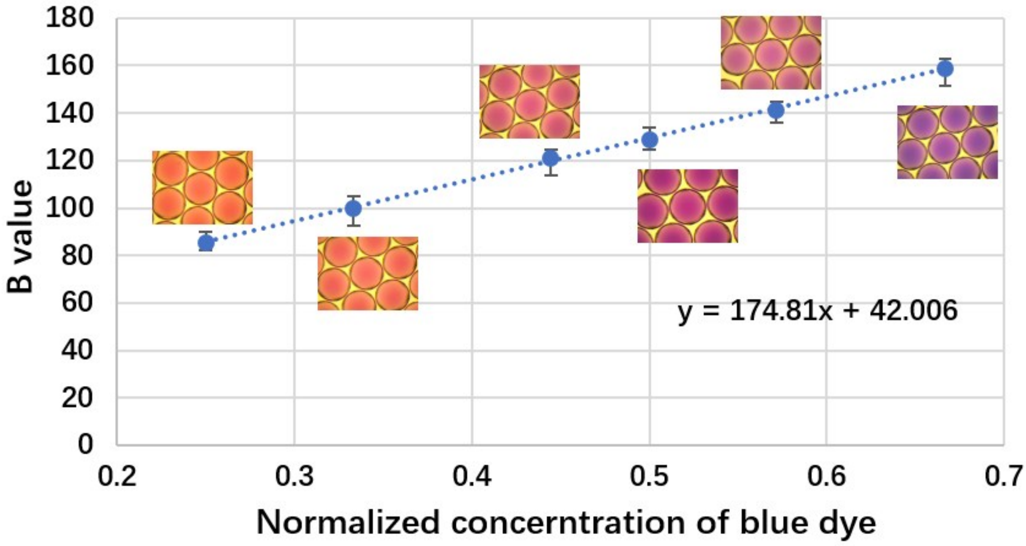

Figure S 3 Calibration curve shows that the B value is roughly proportional to the concentration of blue dye

Droplet array generation

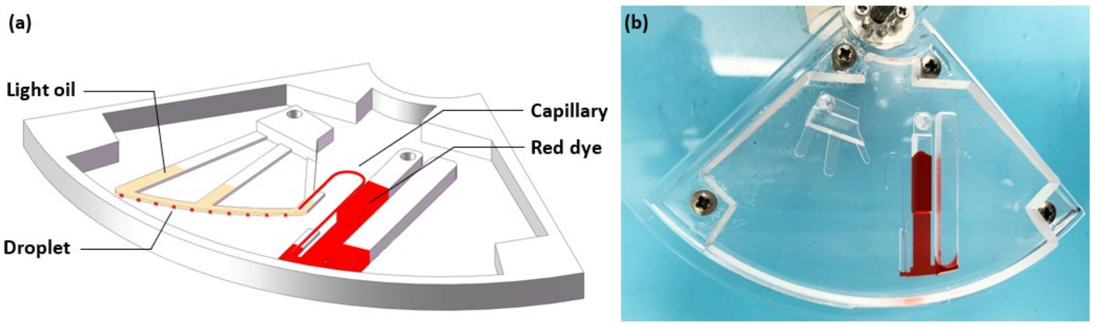

Figure S 4 (a) Schematic sketch of a simple droplet array preservation device (b) A fabricated sample of the chip for demonstration

In order to demonstrate the possibility of using periodic droplet generation to better collect individual droplet, we designed a simple structure to preserve every single droplet. Figure S 4 (a) shows the schematic sketch of this design. By applying low rotating speed and high rotating speed periodically, a droplet array with order was formed (Figure S 4 (b)). The experimental results show the potential of our structure in manipulating individual droplet.

ANOVA test between three groups

To see whether there is a significant difference between the reference and the droplets fused through our device under different rotating speed, we choose to use one-way ANOVA test to compare the results.

First, we define null and alternative hypothesis：

H_0: $\mu_{ref}=\mu_{800rpm}=\mu_{1200rpm}$

H_1: not all means are equal

Then we calculate the degree of freedom:

df_t=N-1=60-1=59

df_b=k-1=3-1=2

df_e=N-k=60-3=57

According to the F-table, when α=0.05, df_b=2, df_e=57, F value is 3.159.

Then calculate test statistics:

$SS_b=\frac{\sum(\sum a_i)^2}{n}-\frac{T^2}{N}=7.09\times10^{-4}$

$SS_e=\sum Y^2-\frac{\sum(\sum a_i)^2}{n}=0.0067$

$SS_t=\sum Y^2-\frac{T^2}{N}=0.0075$

Between groups mean square: $MSb=\frac{SS_b}{df_b}=3.54\times10^{-4}$

Within-groups error mean square: $MSb=\frac{SS_e}{df_e}=1.18\times10^{-4}$

F ratio (F) $=\frac{MS_b}{MS_e}=2.9957<3.195$

Therefore, we accept the null hypothesis H_0, which means there is no significant difference between the three groups. In another word, the droplets fused through our device under different rotating speed is in good accordance with the reference.

Cell transfection experiment

During the cell transfection experiment, we observed the fused droplets through a confocal microscope. Detailed Figures were provided as follows.

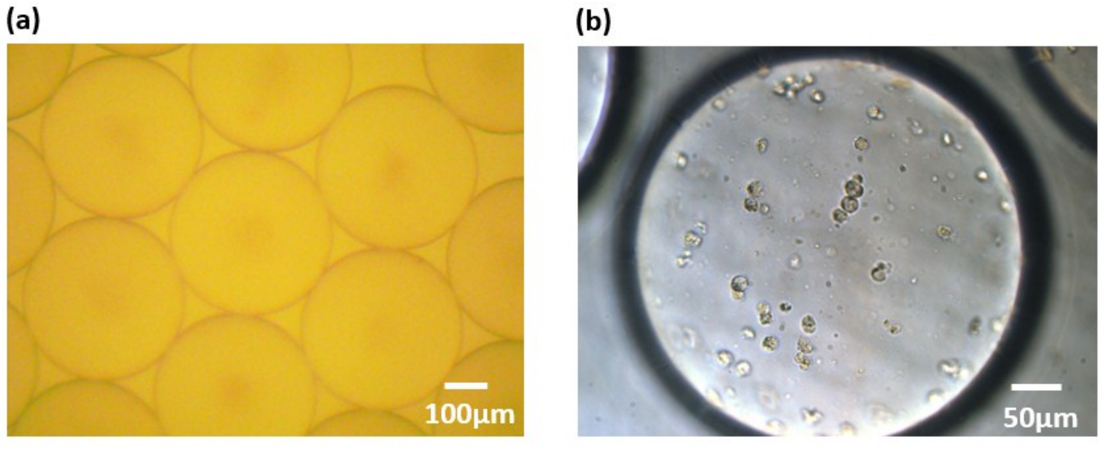

Figure S 5 (a) Droplets generated using on-disc droplet fusion device. (b) Detailed image of cells inside droplets.

Perovskite synthesis experiment

Based on data obtained from five speeds, we calculated the theoretical ratios that we can achieve according the data shown in Figure 3. Then we use a pipette (~10 µl) to mix the 2D and 3D components precisely. We use these manually mixed solutions as the control reference for the perovskite synthesis process and measured their photoluminescence intensities. Then we compared the peak wavelengths of the reference against the ones synthesized using our LOAD device.

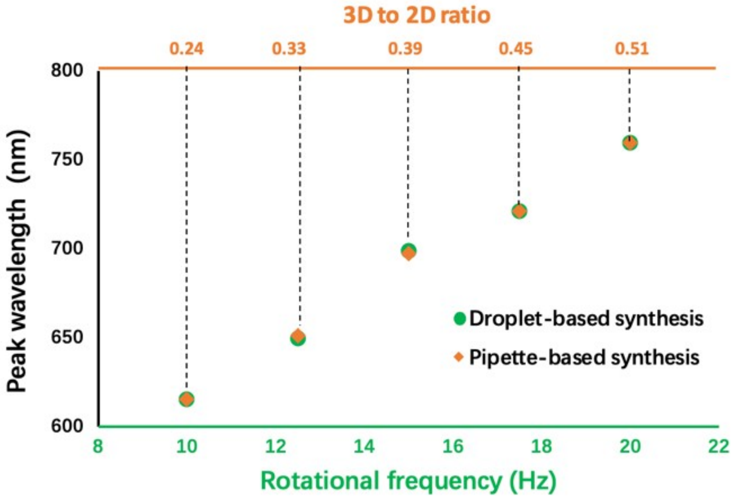

Figure S 6 Comparison of experimental results between droplet-based synthesis controlled by rotational frequency and pipette-based synthesis with calculated 3D to 2D ratios.

Supplementary references

1. F. Schuler, M. Trotter, M. Geltman, F. Schwemmer, S. Wadle, E. Dominguez-Garrido, M. Lopez, C. Cervera-Acedo, P. Santibanez, F. von Stetten, R. Zengerle and N. Paust, *Lab Chip*, 2016, **16**, 208-216.