Supplementary Information

A Programmable microfluidic static droplet array for droplet generation, transportation, fusion, storage, and retrieval.

Si Hyung Jin,\textsuperscript{a} Heon-Ho Jeong,\textsuperscript{a} 'Byungjin Lee',\textsuperscript{a} 'Sung Sik Lee,\textsuperscript{b} Chang-Soo Lee \textsuperscript{*a}

\textsuperscript{a} Department of Chemical Engineering, Chungnam National University, Daejeon, Republic of Korea. E-mail: rhadum@cnu.ac.kr; Tel: +82 42 821 5896.

\textsuperscript{b} Institute of Biochemistry, Department of Biology, ETH Zurich, Zurich, Switzerland
Fig. S1 Schematic illustration of the experimental setup. SDA device is observed using inverted fluorescence microscopy. Positive pressure and negative pressure from nitrogen gas and the air compressor are introduced to the SDA device via a computer-controlled solenoid valve.
Fig. S2 Schematic illustration of a detailed design of a hydrodynamic trap, including the trap valve and the fluctuation valve. (A) 3-dimensional view of a hydrodynamic trap unit for aqueous droplet trapping. Green and red lines are the activated trap valve and fluctuation valve, respectively. The trap valve is expended upward by introducing positive pressure in the control layer. The fluctuation valve is expended downward by introducing a negative pressure in the control layer. (B) Schematic diagram of the expended trap valve and fluctuation valve. Cross-sectional view of a-b in part A representing a trap valve (top). In the top image, the capillary path is formed by partially closing a trap valve. Cross-sectional view of c-d in part B representing a fluctuation valve (bottom). In the case of the bottom image, the height of the reaction chamber is increased because the fluctuation valve is expended downward.
Fig. S3 Droplet generation on demand in a programmable droplet generation unit. (A) Schematic diagram and time-lapsed images showing the process of droplet generation. The reagent droplets can be generated on demand by the switching of the droplet generation valve. (B) The volume of the reagent droplet versus valve opening time. Insets of micrographs represent corresponding volumes of droplets. The volume of a droplet is calculated by image analysis of a captured microscope image. The calculated volumes are 17 pL to 82 pL, respectively, from 30 ms to 100 ms.
**Fig. S4** Micrograph of sequential loading of droplet. The number of reagent droplets in a microwell is related to the volume of the generated droplet. (A) Triple sequential loading is achieved using 14 to 17 pL droplets. (B) Double sequential loading is achieved using 23 to 25 pL reagent droplets. (C) Single sequential loading is achieved using a 50 to 55 pL reagent droplet.
Fig. S5 Schematic diagram of the fluctuation process. (A) 3D illustration of a hydrodynamic trap containing an integrated valve. Green and red represent trap valve and fluctuation valve, respectively. White and black arrows represent applied negative and positive pressures, respectively. (B) Cross-sectional view of a-b in Fig. 5A during fluctuation. (C) To enhance the mixing efficiency within droplets, negative pressure and positive pressure are alternatingly applied through the fluctuation valve to apply vibration to the droplets and continuous phase. The cycle of a fluctuation is 1 Hz. (D) Cell tracking images to monitor the vortex flow in droplet. (E) Quantitative measurement of total moving distance of each yeast cell.