Electrospray microarray platform for bulk generation of highly monodisperse cell-like compartments

Kirti Sharma[1], Noritaka Minami[1], Phan Trong Tue[1], Yuzuru Takamura[1,2] and Manish Biyani[1,2,3]
[1]Department of Bioscience and Biotechnology, JAIST, JAPAN
[2]Center for Single Nanoscale Innovative Devices, JAIST, JAPAN
[3]BioSeeds Corporation, JAPAN
E-mail: biyani@jaist.ac.jp

The generation of cell-like compartments by *in vitro* compartmentalization (IVC) date back to 1998 by Tawfik and Griffiths for efficient cell-free system in synthetic biology. Over the two decades, three main approaches have been widely used for IVC as i) use of homogenizers and vortexing in conventional methods, ii) microfluidics-based approaches iii) use of single nozzle in electrospray [1]. Each technique has its own demerits from polydisperse to low-throughput generation to time consuming respectively, and thus, these approaches limit the application of IVC in the chemical and biological sciences. Electrospray incorporating single nozzle generates monodisperse and fL-sized droplets but it consumes hours-to-days for encapsulation of µl scale reaction with a limit of library size to $10^{8\text{-}9}$. Hence, in this work we present a novel platform by integrating micro-hole chip with immersed electrospray for ultrahigh-throughput generation of highly monodisperse water-in-oil or agarose-in-oil compartments.

The set-up of Micro-Hole Array Electrospray (µHAES) system is shown in Fig. 1(a) where a conductive aqueous solution is electrospray through an electrified micro-hole chip containing an array of 7x7 mm (24x16=384 holes) in an immiscible phase (mixture of oil and surfactant). A jet of water-in-oil droplets are obtained into the oil chamber when voltage of 1000 V was applied through the micro-hole array thereby generating bulk w/o droplets as shown in Fig. 1(b).

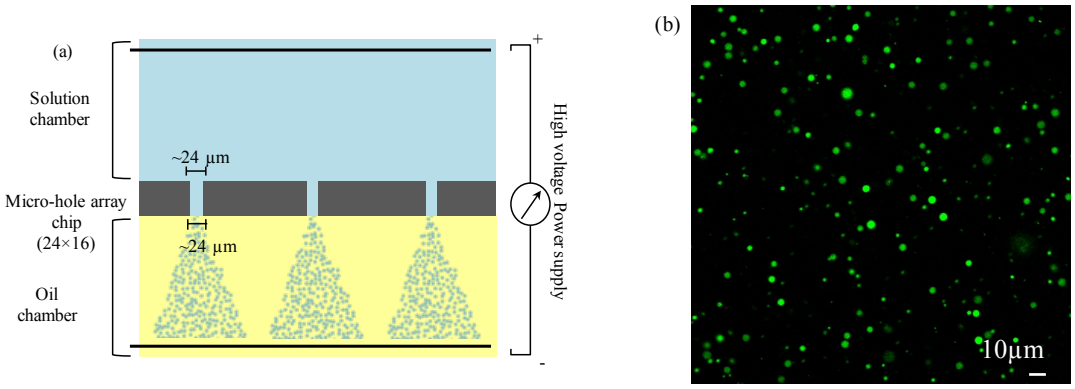

Figure 1: (a) The concept of Micro-Hole Array Electrospray (µHAES) system and (b) fluorescent image of agarose-in-oil droplets produced by µHAES.

In our novel µHAES system, we not only can reduce the time of encapsulating cell-free reaction (10 µl) in 1fL IVC to just 5 minutes but can also increase library size to $10^{11\text{-}12}$ compared to 55 hours and $10^{8\text{-}9}$ library size of single nozzle electrospray therefore, establishing an ultrahigh-through w/o droplet generation platform in less time with high library size.

Reference

[1] B. Sharma, Y. Takamura, T. Shimoda and M. Biyani, Sci. Rep., 6, 26257 (2016).

Keywords: *In vitro* compartmentalization (IVC), Immersed electrospray, Micro-Hole Array Electrospray (µHAES) system, Library size.