Generation of Droplet in Size Over a Wide Range by Microfluidic Control

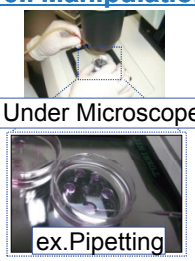
Lin FENG, Yoko YAMANISHI, Fumihito ARAI
Department of Bioengineering and Robotics, Tohoku University

Abstract:

We have successfully produced **emulsion droplets on a chip with size-control and on-demand droplet generation by using magnetically driven microtool (MMT).** The MMT has parallel plate structure to be constrained in translational motion. With a lateral motion of MMT in microchannels, the continuous phase can be cut into different size of droplets and the dispersed phase flow can inflow into the microchannels **by the movement of MMT to obtain both of size-controlled and on-demand droplets actively.** The size range of the produced **droplet was improved three times as large as the previous system by employing novel hydraulic design of the chip, and also the leakage of the fluid was successfully prevented** when it is chopped by using MMT.

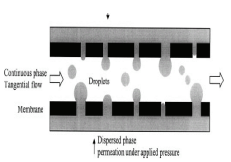
Background:

Cell Manipulation



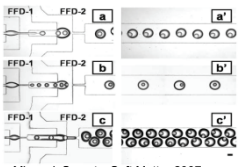
Conventional Design

Emulsifation



J. Chem. Technol. Biotechnol 79: 209-218 2004

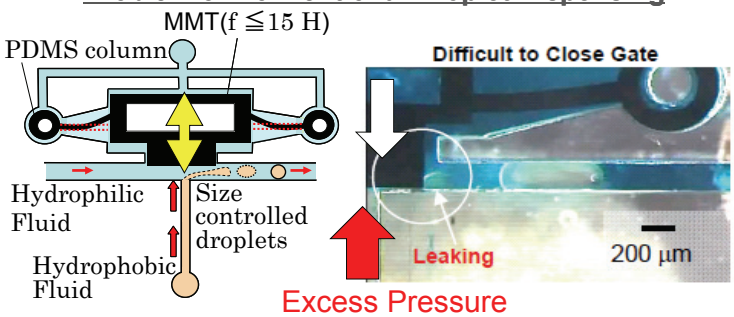
Passive Droplet dispensing



Minseok Seo etc, Soft Matter 2007

By changing Flow Rate

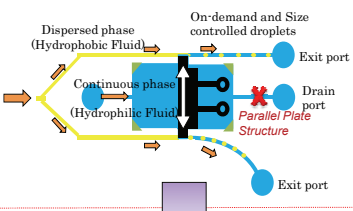
Problem of Conventional Droplet Dispensing



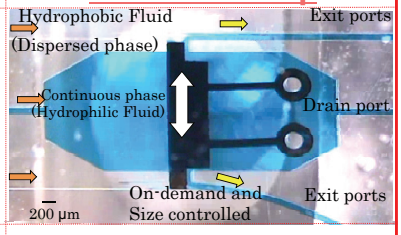
Fabrications :

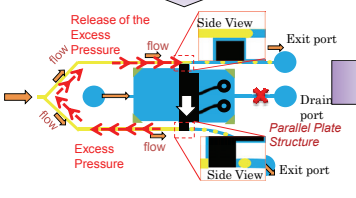
–Concept View-

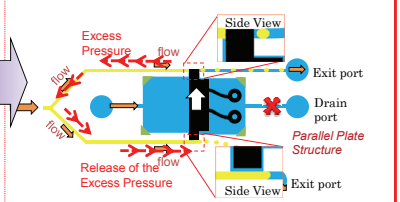
Flow Condition



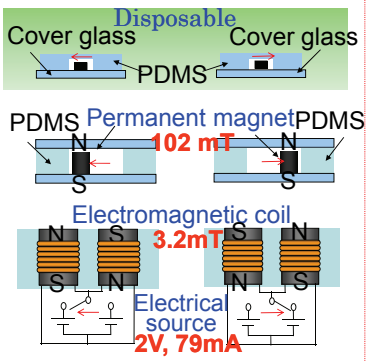
Fabricated Chip



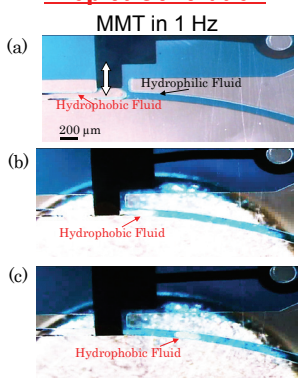




Experimental Setup

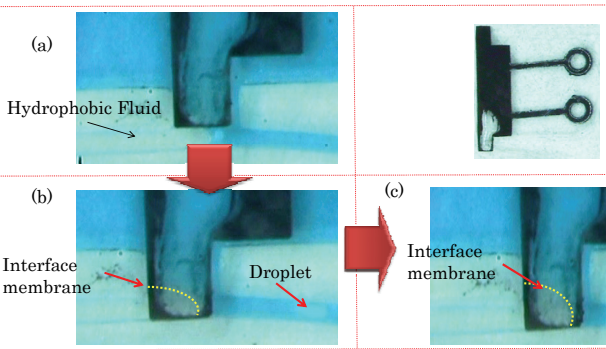


Droplet Generation



Analysis:

Transparent MMT for System Analysis



2D Analysis in Microtube

Derivation process

Viscous resistance force:

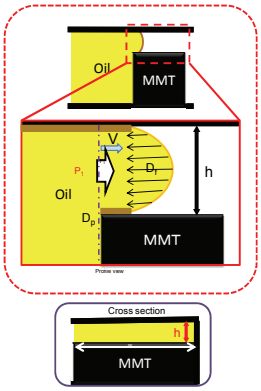
Re = ρ·A·v/μ = 9.41x10^{-11} ;
Reynolds number
D = D_f + D_p ;
D_f : Viscous resistance force
D_p : Fluid drag
D_p = 1/2·ρ·v^2·C_p·S =1.89x10^{-27} N
D_f = 2μ·v/A = 9.5x10^{-8}N
So D ≈ D_f .
P_D = D/S =12 Pa

Conclusion:

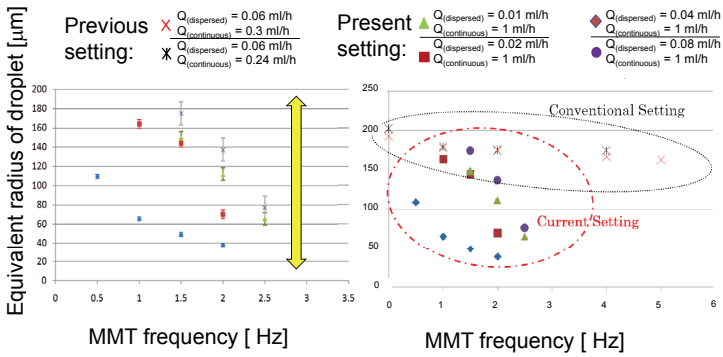
So when the P_1 < P_D, this system is stable and can generate the droplet successfully.

	Density (g/cm^3)	Viscosity (g/(cm•s)) (Pa•S)	Surface tension (mN/m)
Olive oil	0.90	0.081	20-30 (25)
Ethanol	0.79	0.0090	22

Symbols	Definitions
P_D	Total resistance pressure (Pa)
P_1	Fluid pressure (Pa)
A	Cross section diameter (m)
V	Fluid velocity (m/s)
S	Cross section area



Improvement of Current Setting



Conclusions:

- On-demand and size control of droplet dispensing is produced successfully
- The size in a wide range of produced droplet are produced by changing the flow rate and MMT frequency from 40 -180 μm throughout the MMT frequency (1-3 Hz).
- The dynamic range of the droplet size produced was three times as large as the range of the size of droplet produced in the conventional setting.

References:

Lin Feng, Yoko Yamanishi, and Fumihito. Arai, "Generation of Droplet in Size Over a Wide Range by Microfluidic Control", MHS 2009 & Micro-Nano Global COE, p.139-144, Nagoya, 2009.