A Preliminary Design of a Hydrodynamic Microtrap for Capturing Aqueous Droplets in Oil Media

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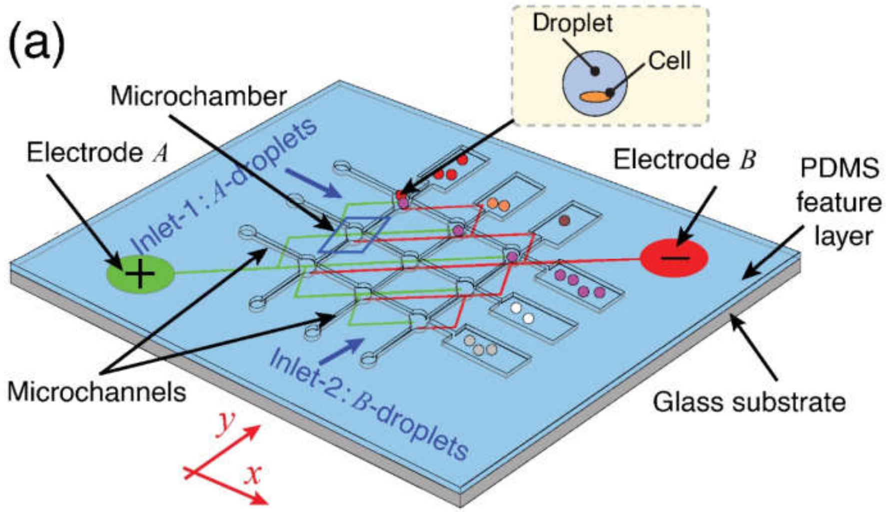
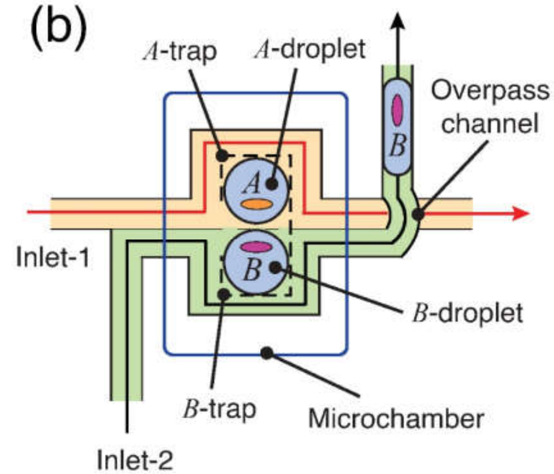
Overview and Objective



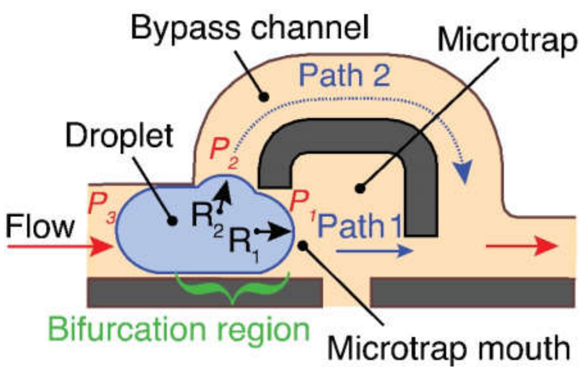
An example droplet-based microfluidic system for high-throughput screening of eukaryotic cells – cell apoptosis and synthetic lethality tests

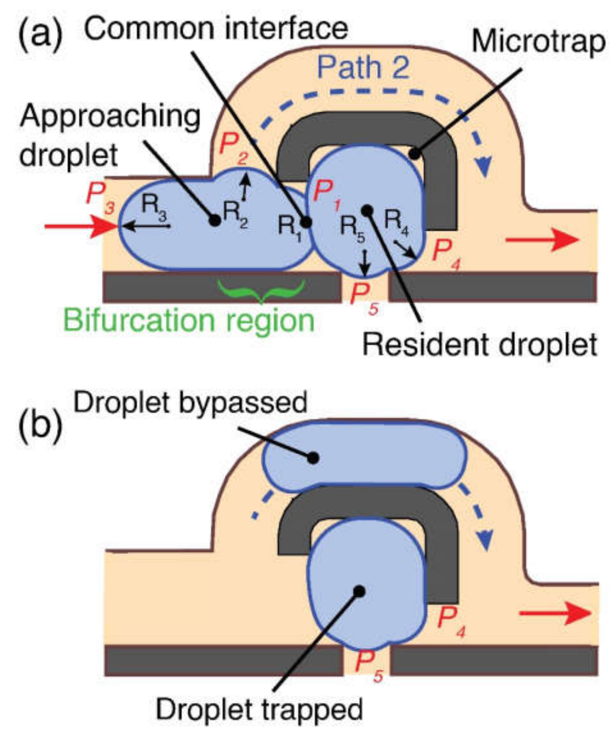


A schematic sketch of hydrodynamic microtraps (top view)

Objective: To analyze the *effect of fluid surface tension* and *oil speed* on the *aqueous droplet behavior in the hydrodynamic microtraps* through parametric studies

Theory





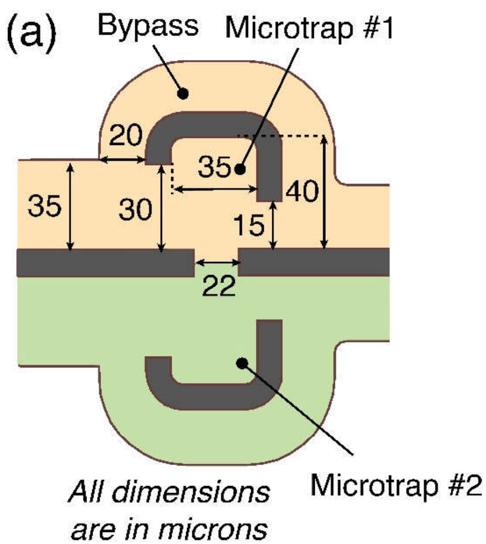
<u>Laplace pressure relation</u>

$$\psi = P_2 - P_1 + \gamma\left(\frac{1}{R_2} - \frac{1}{R_1}\right) > 0$$

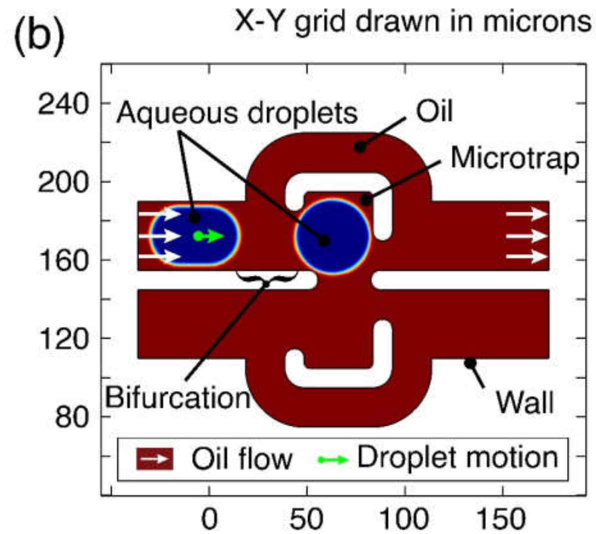
Condition for a droplet to enter the trap (Path 1), where $P_{1,2,3}$ are hydrostatic pressures

Condition for a following droplet to enter the bypass channel (Path 2), where $P_{1,2,3,4,5}$ are hydrostatic pressures

Simulation Setup

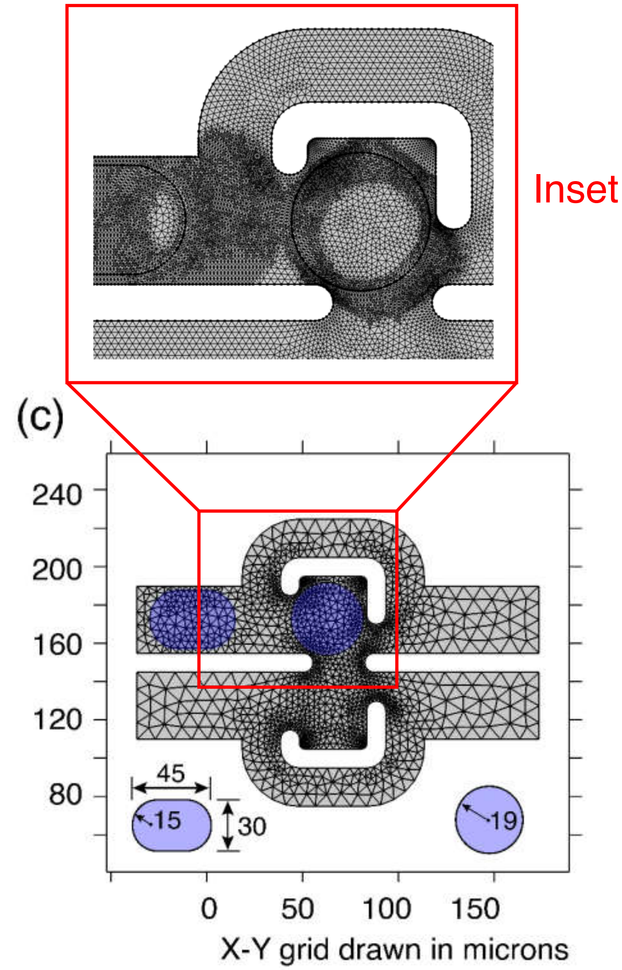


Microtraps with given geometric parameters



2-D CAD model of the simulation setup

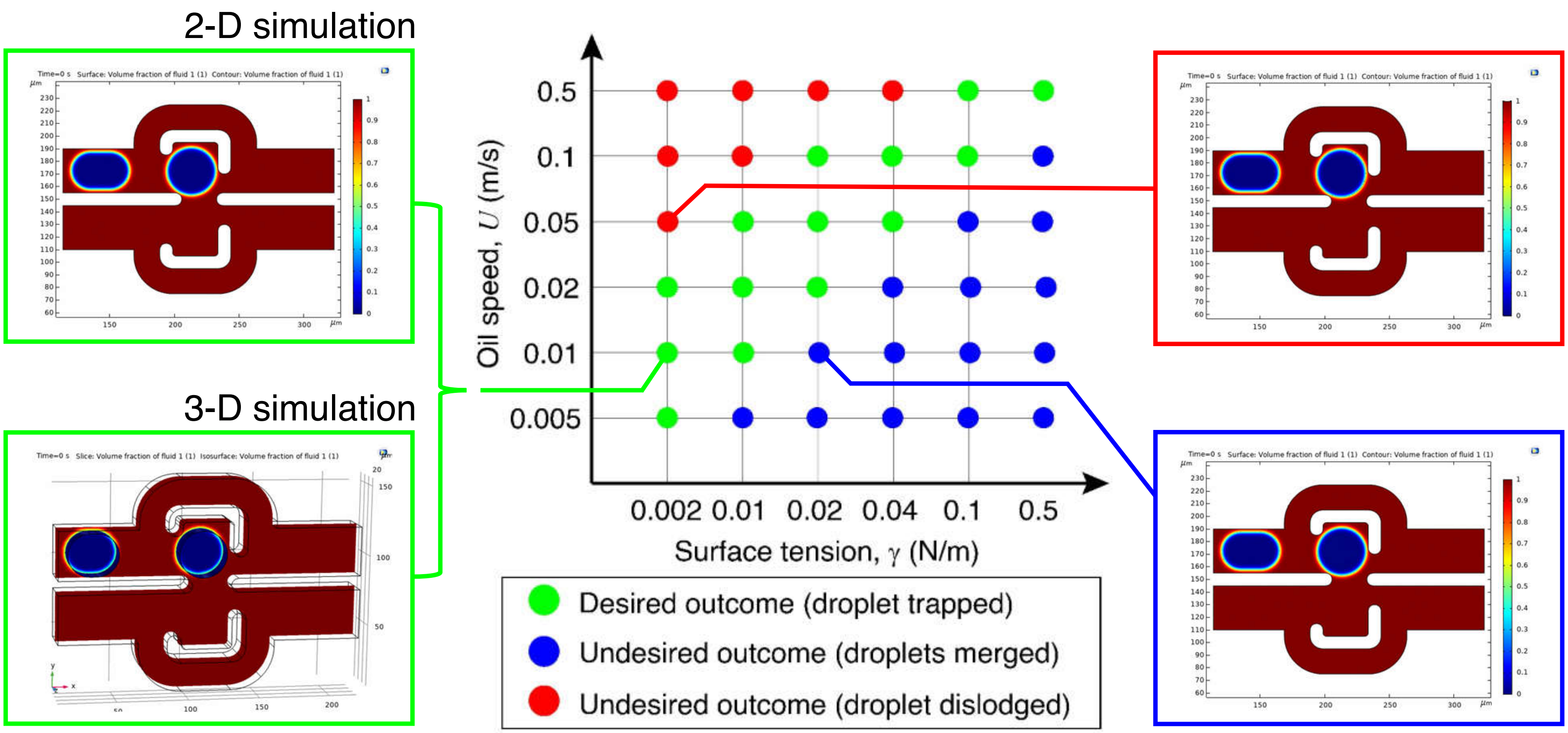
Adaptive mesh in critical areas



Representative mesh

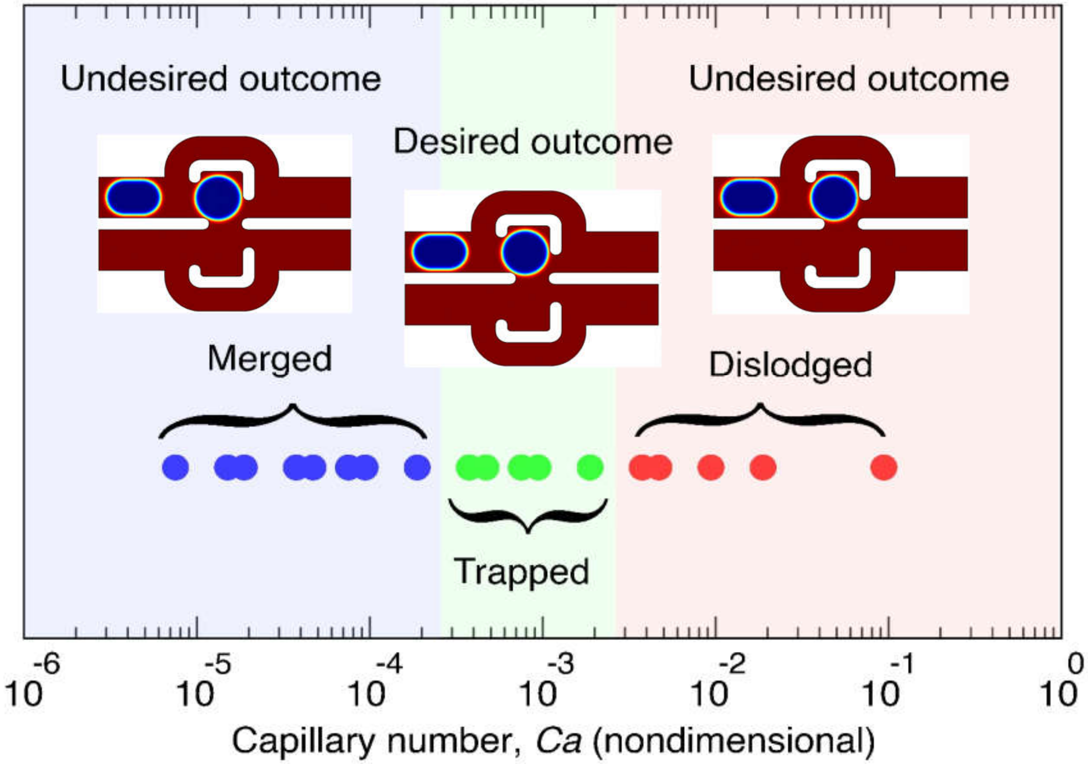
Surface tension coefficient	(0.002–0.5) N/m
Mesh element size/type	Extra fine/Free Triangular
Materials	Water/Oil
Inlet conditions (oil)	(0.005–0.5) m/s
Wetted wall contact angle	180°

Results



For successful trapping of a droplet in the microtrap, the magnitude of the fluid (oil/water) surface tension γ and the oil speed U should be on the same order of magnitude.

Results (2)



Design chart showing fate of the droplet as various capillary number ranges

For medium Ca $O(10)^{-3}$ the incoming droplet gets trapped and the following droplet takes the bypass

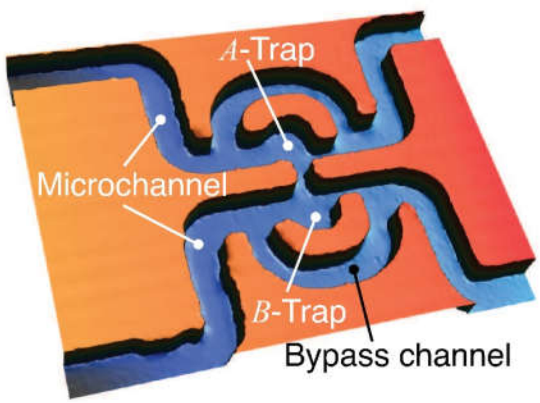
<u>Capillary Number</u>

$$Ca = \frac{\mu U}{\gamma}$$

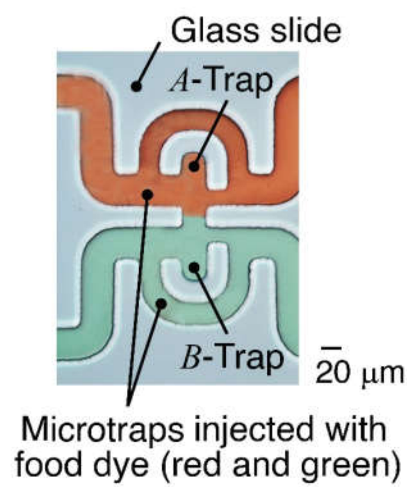
μ - dynamic viscosity of oil
U - oil speed
γ - surface tension coefficient

Future Work

The COMSOL Multiphysics model presented here will be fully validated with experiments for different fluid properties and fluid flow conditions.



Representative microtrap image obtained using laser confocal microscope



Representative microtrap image obtained using an inverted microscope

Acknowledgements

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