A Comparison of the Continuous and Discrete Approach for Liquid Manipulation

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Introduction: The objective of this work is to achieve a complete and rapid efficient mixing of numerous sample in micro-scale devices of microfluidic system. A comparative study of continuous and discrete fluid mixing has been reported to improve the mixing efficiency of the microfluidic devices.

Computational Methods: The computational analysis of the continuous micro-channel fluid flow has been executed by using a mixing based model where two different physics in model wizard has been selected. In the physics of 'Single Phase Fluid Flow', the 'Laminar flow' model has been selected for flow analysis. Similarly, in the physics of 'Chemical Species Transport', 'Transport of Diluted Species' has been selected.

In contrast, for discrete type fluid flow (assuming the fluid flow as incompressible flow and neglecting the inertial term i.e. Stokes flow) AC/DC, Fluid Flow and Chemical Species Transport physics are used for simulation in COMSOL platform. In particular, Electric Current (ec), Laminar Two-Phase Flow, Moving Mesh (tpfmm) for simulation of Lippmann-Young equation i.e. change in contact angle for droplet deformation, additionally Level Set (tpf) with Electric Current (ec) for simulation of droplet transport and Convection-Diffusion Equation (cdeq) for mixing two droplets having different concentration. Further, the model has been simulated by considering 'Stationary Solution'. Modelling is done by considering the fluid as an incompressible Newtonian liquid in micro channels to be mixed.

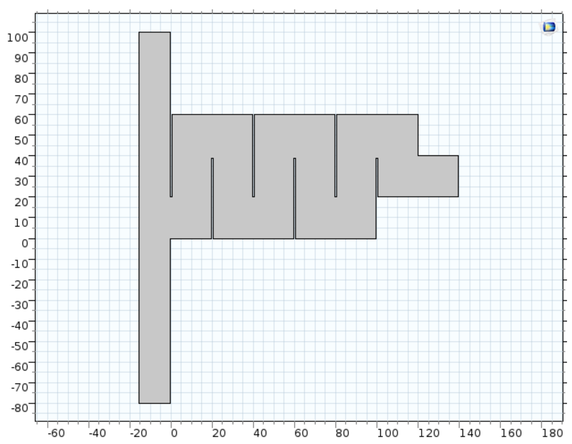

Figure 1. The geometry for continuous fluid mixing

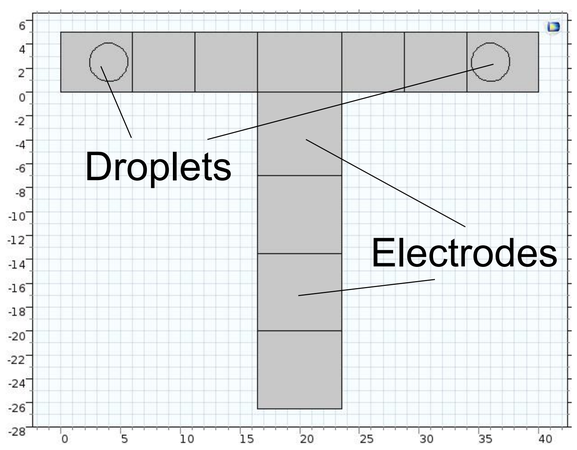

Figure 2. The geometry for discrete fluid mixing

Results:

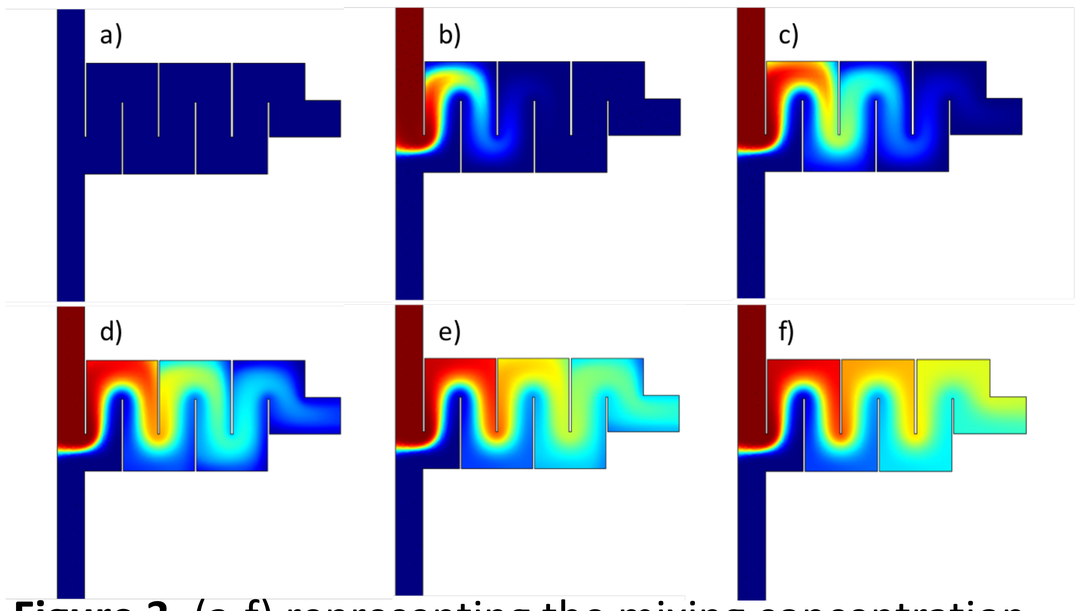

Figure 3. (a-f) representing the mixing concentration for continuous mixing.

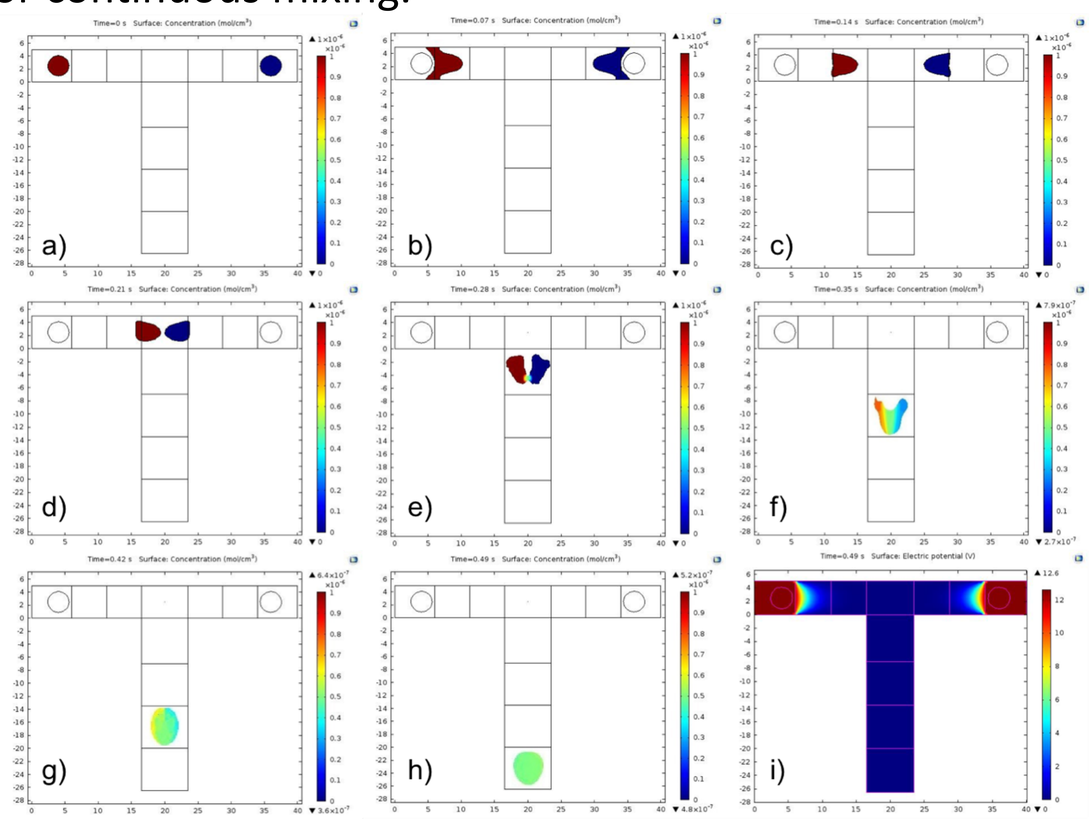

Figure 4. (a-h) representing the mixing concentration for discrete mixing, (i) The electric field simulation of 1st and 2nd electrodes

Conclusions: It has been observed that the discrete flow has a better mixing efficiency compared to the continuous flow. Also the discrete type fluid flow has certain advantages over continuous fluid flow like re-configurability, low reagent volume, all the control parameters are in electrical domain and more importantly the devices have no mechanical components.

References:

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