भारतीय प्रौद्योगिकी संस्थान हैदराबाद
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An Effective Design and Simulation for Microfluidic Passive Mixing with Geometric Variation

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Advances in Microfluidics & Lab -on –a- chip

Introduction

To accomplish a complete and rapid mixing of numerous sample in micro-scale devices is the main objective of microfluidic devices. generally in micro-scale devices low Reynolds number is considered which reflect that the viscous force also has a great influence. Thus, the flow would be laminar and diffusion plays a dominant role in microfluidic mixing instead of turbulence. In this study we have designed a passive microfluidic mixer to mix the fluid without any external energy force. Here we have observed, the mixing efficiency is improving with appropriate choice of geometric variation. In this paper a passive microfluidic mixer with and without obstacles has been designed and simulated to improve the mixing efficiency of fluids.

Method

All the simulation work has been done by using Comsol Multiphysics software. We chose Laminar flow (spf) and Transported diluted species (tds) for the simulation of microchannel fluid mixing by coupling of convective-diffusion and Navier-Stokes equation. Two fluid with different concentration of 0 and 1 mol/m^3 respectively. Ideally we would achieve the complete mixing at the last reservoir with average concentration of both fluids i.e. 0.5 mol/m^3.

Navier-Stokes Equations

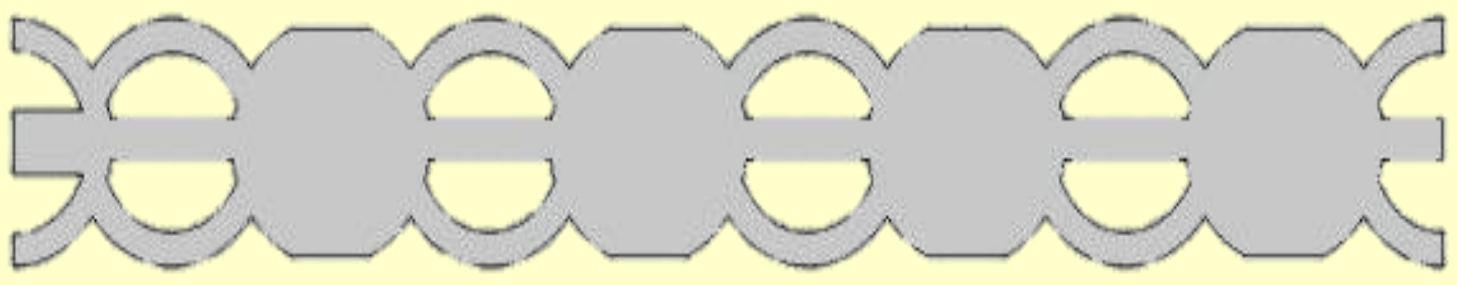
$$\rho\left(\frac{\partial u}{\partial t}+u\cdot\nabla u\right)=-\nabla p+\nabla\cdot\left(\mu(\nabla u+(\nabla u)^T)-\tfrac{2}{3}\mu(\nabla.u)\mathbf{I}\right)+\mathbf{F}$$

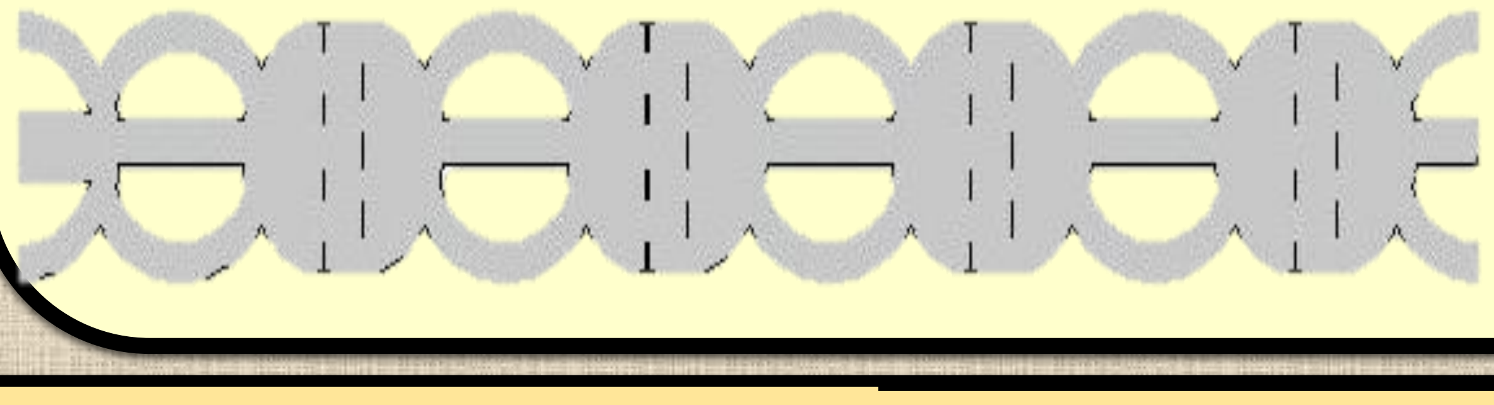
$$\nabla\cdot \mathrm{u}=0$$

Convection and Diffusion

$$\frac{\partial c}{\partial t}+(V.\nabla)c=D\nabla^2 c$$

Geometry

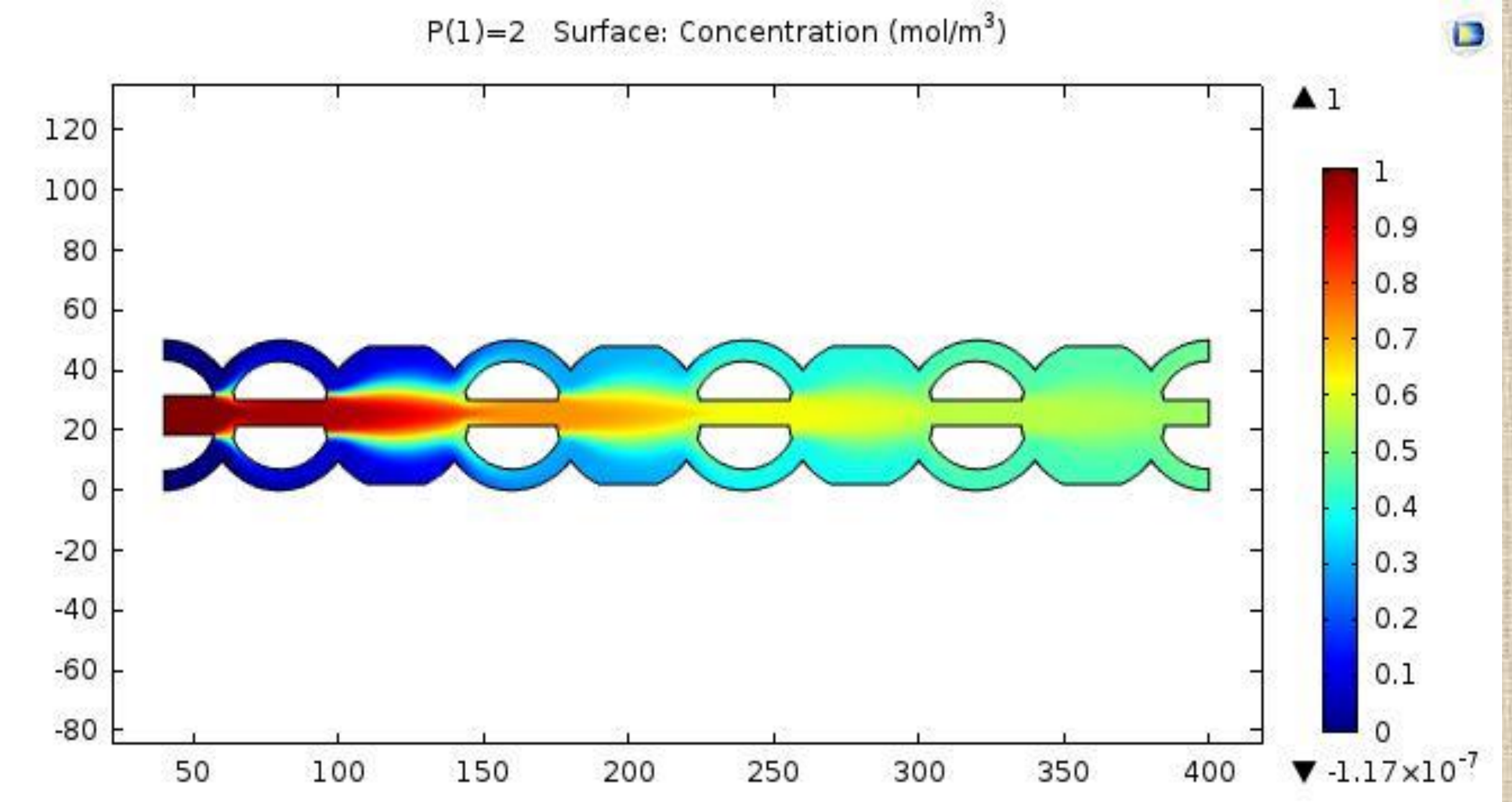

(a) Without barrier


(b) With barrier

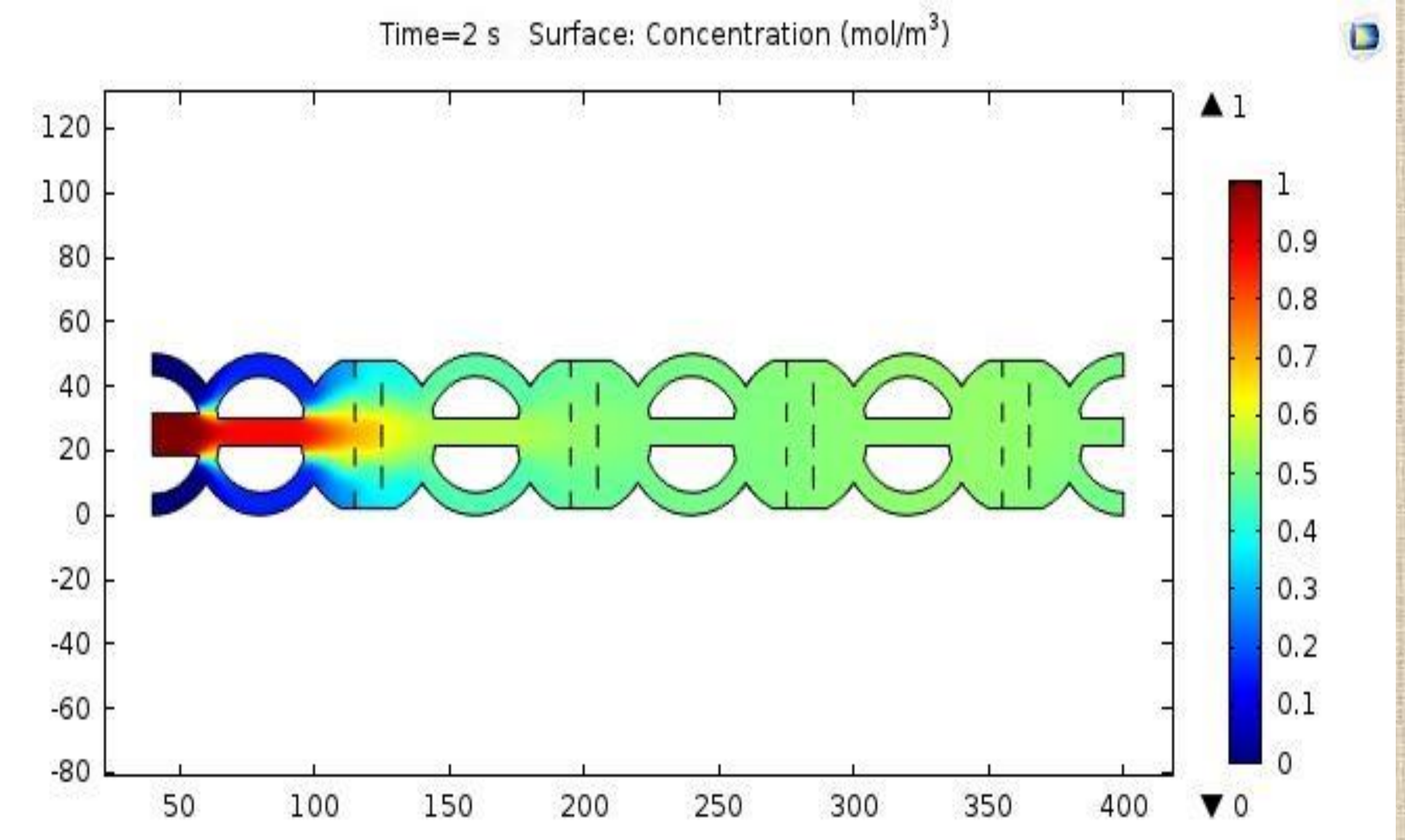
Result and Discussion

As a result we achieved the complete mixing at the third reservoir. The significant mixing has been performed with ±0.03 mol/m^3 tolerances. The efficiency of mixing is 96 with the corresponding values of 0.47 and 0.53 mol/m^3.

(a)



(b)



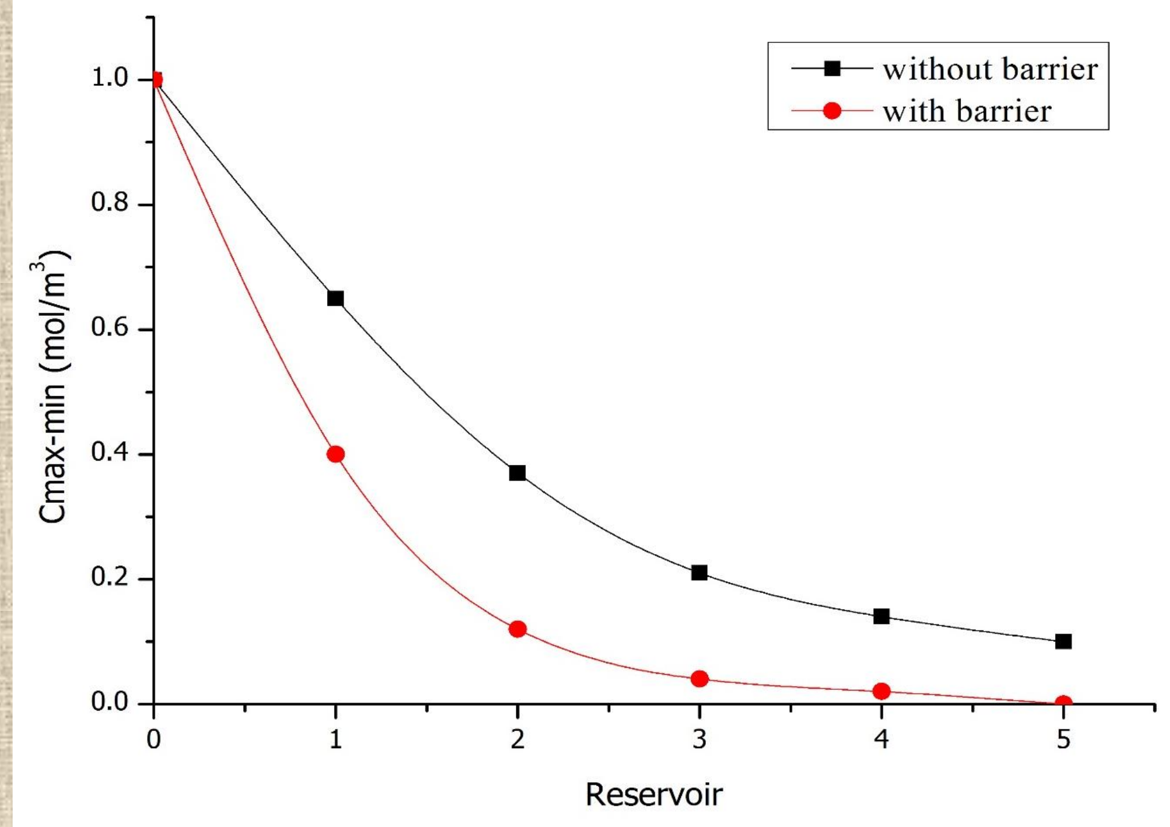
(a) Mixing concentration without barrier

(b) Mixing concentration with barrier

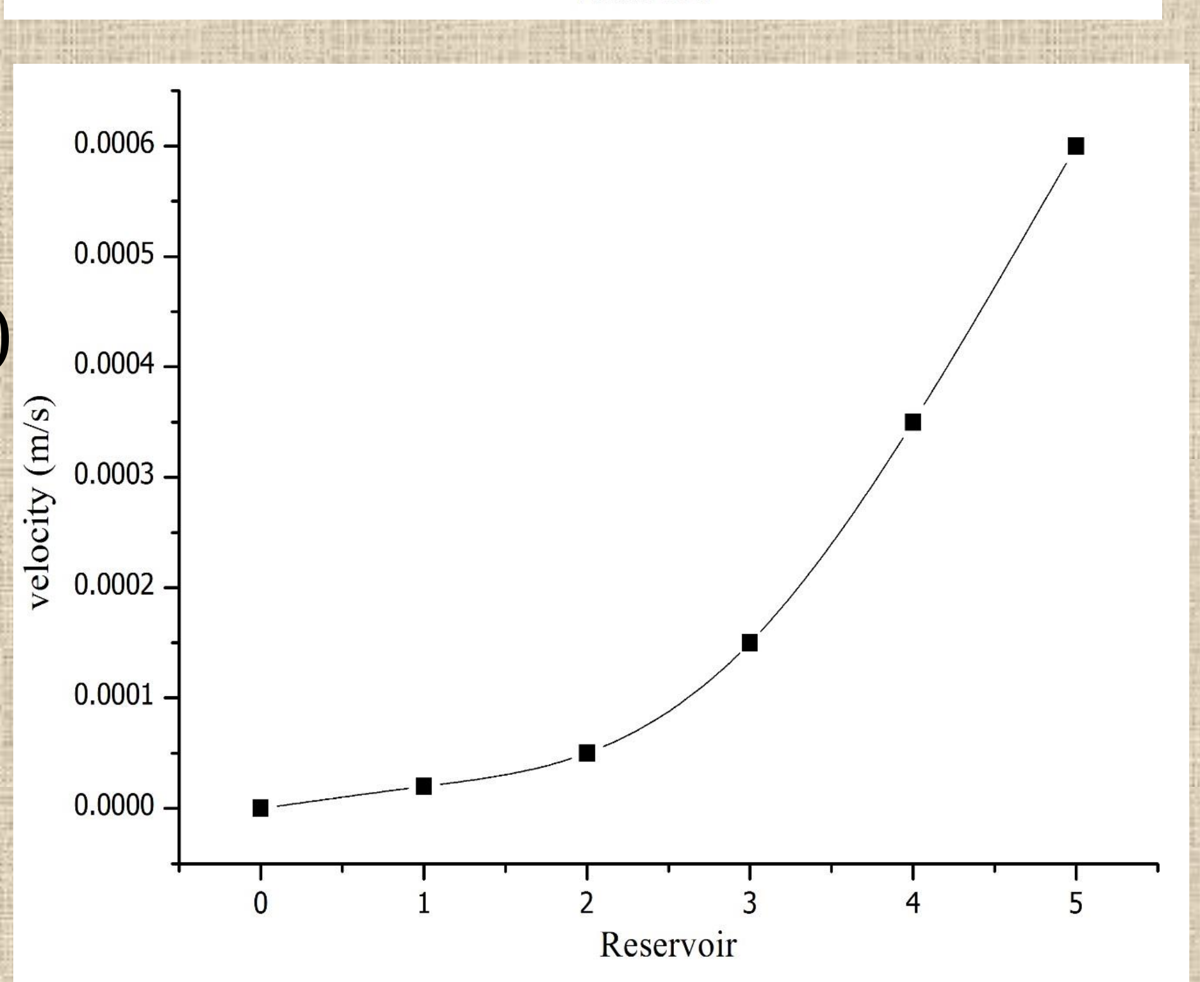
(c) Comparison between mixing efficiency of with and without barrier

(d) Velocity Vs Reservoir (Mixing length)

(c)



(d)



Conclusion

In this paper we have compared the mixing efficiency of micro-channel with and without barrier. As a result we have achieved the complete mixing in the third reservoir of device with barrier compared to without barrier. We can conclude that the geometry variation has great impact on the mixing efficiency of microfluidic device. In addition, this model could be useful in the macromolecule dynamics, single molecule studies, protein folding/ misfolding as well as in the field of μTAS and lab on a chip devices.

References

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