Computational Analysis of Electroosmotic Flow in a Microchannel Using Finite Volume Method

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1. INTRODUCTION & OBJECTIVE

In electroosmotic flow, the motion of liquid is induced by an external electric field across a microchannel. Due to an external electric field, the Coulomb force acts on the mobile ions present in the electrolyte liquid, due to which the flow of liquid takes place. Electroosmotic flow in microchannel deals with the low Reynolds number effects due to weak inertial forces. Electroosmotic flow-based devices are widely used in microfluidic systems like microfluidic pumps, fluid control devices, chemical separation analysis and drug delivery. In this paper, a computational model is developed in MATLAB to study electroosmotic flow in a microchannel by solving the continuity, Navier-Stokes equations along with Poisson-Boltzmann and Nernst-Planck equations. The governing equations are non-dimensionalised and are discretized using finite volume method on a staggered grid system. Parametric study is conducted for Reynolds number, external electric field, Peclet number, channel dimensions and ionic concentration.

2. RESULTS

From velocity profile shown in figure 1, an increase in velocity near the walls due to electroosmosis is clearly observed. But away from the wall effect of electroosmosis decreases and velocity profile becomes similar to that of plane Poiseuille flow. In the next stage, simulations are conducted for oscillatory flow. In this case, vortex formation is observed and due to electroosmotic velocity near the walls the vortex formed get straightened up. Further by solving Nerst-Planck equation, the effect of Peclet number on the concentration is determined which is measure of mixing in electroosmotic flow and same is depicted in figure 2. It can be seen that by increasing Peclet number, the concentration is not effectively distributed which indicates poor mixing in the channel. Further simulations are carried out for various Reynolds number and channel length. By increasing Reynolds number and channel length, the concentration is distributed effectively.

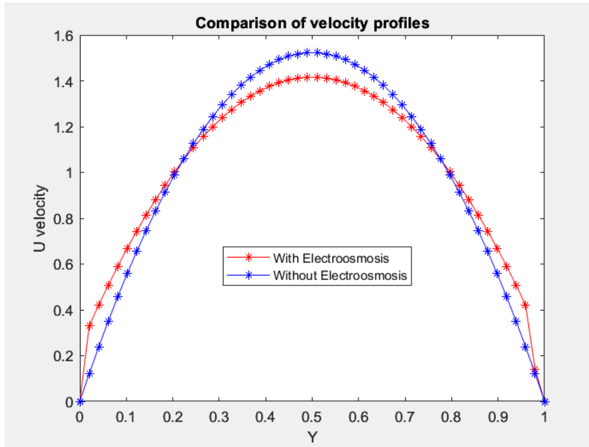
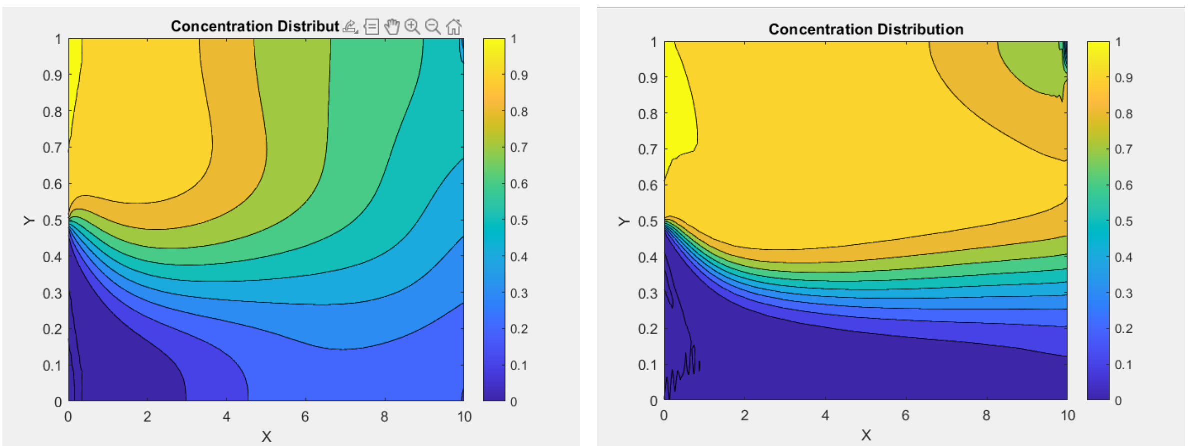


Fig. 1: Comparison of velocity profiles



a. Peclet number = 100

b. Peclet number = 500

Fig. 2: Concentration distribution

Keywords: Microfluidics, Electroosmotic Flow, Electrical Double Layer, Flow Mixing, Oscillatory type flow.

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