POISSON BASED MODELING OF DC AND AC ELECTROOSMOSIS IN MICROFLUIDIC CHANNELS

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Two mathematical models of the electrokinetic flow are presented. The models are based on: (i) momentum balance of the electrolyte, (b) continuity equation, (c) molar balances of the components of the uni-univalent electrolyte, and (d) Poisson equation of electrostatics. The electroosmotic flow is induced by the interaction of a surface electric charge with a perpendicularly imposed electric field. Both the models are characterized by the formation of extremely thin surface layers with gradients of electric potential, pressure, concentrations and velocity. In order to solve such problems, an anisotropic mesh of rectangular finite elements is developed.

The first model describes a classical electroosmotic problem – the electrolyte dosing in a microfluidic channel with an axially imposed DC electric field (Fig. 1A, B). Stationary distributions of the model variables are computed for various sets of model parameters: applied voltage, density of the surface electric charge, microchannel diameter, electrolyte concentration etc. The interaction of a low-concentrated biological analyte with a receptor bound on the microchannel walls is studied by means of dynamical simulations.

The second model deals with recently proposed AC electroosmosis that is based on the application of AC voltage on two electrodes of different size. The formed asymmetric electric field pattern causes the zigzag motion of electrolyte in microcapillary with one dominant direction (Fig. 1C, D). The dynamical simulations are aimed at the effects of voltage frequency, electrode size and electrolyte concentration on velocity of the electrolyte flow.

The implementation of the models is carried out in the Matlab/Comsol command mode. Specific advantages and problems of this approach are also discussed.

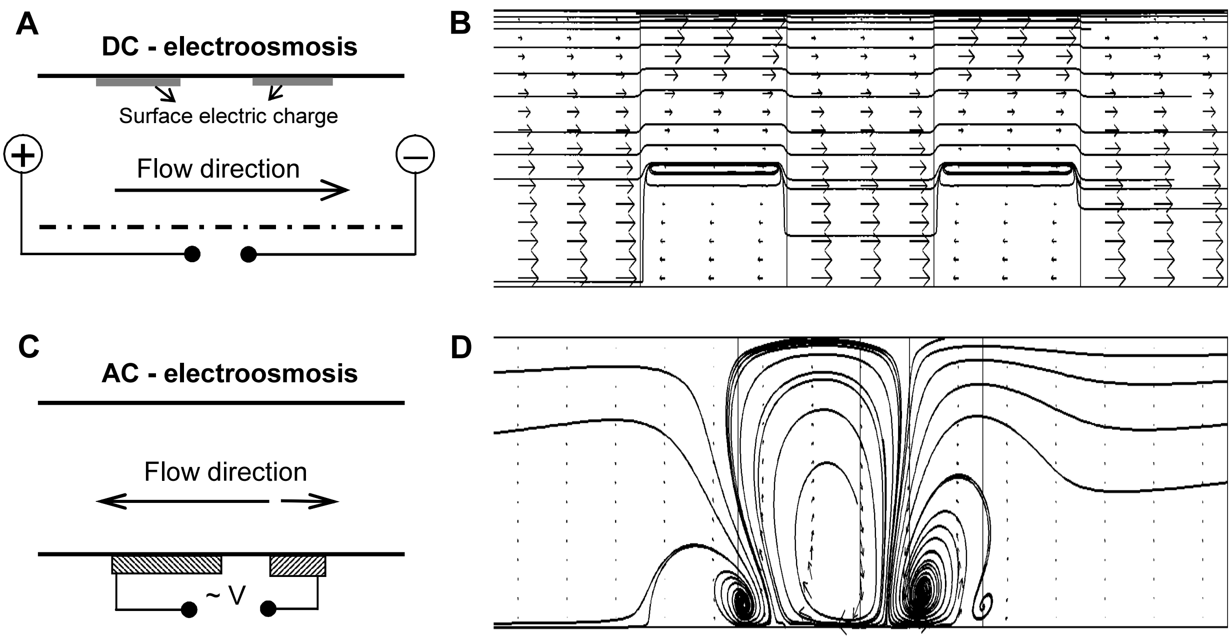

Figure 1: (A) Principle of DC-electroosmosis, (B) DC electroosmosis in a tubular capillary with two areas of superficially bound electric charge, (C) Principle of AC electroosmosis, (D) AC electroosmosis in a rectangular capillary with a periodic field of electrode pairs.

Acknowledgement: The authors thank for the support of the research by the grant of the Grant Agency of Czech Academy of Science KAN208240651 and by the grant of Ministry of Education, Youth and Sport of the Czech Republic MSM 6046137306.