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The electroosmotic flow of non-Newtonian fluid in a cylindrical microcapillary for high zeta potential

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Due to the increasingly wide study of the electroosmotic flow of bio-fluids in microfluidic systems (lab-on-a-chip, µTAS), a parametric study for the electroosmotic flow of the power-law fluid is conducted for more practical boundary condition, i.e., high zeta potential at the wall of a cylindrical microcapillary. The electric potential distribution across a cylindrical microcapillary is described by the complete Poisson-Boltzmann equation applicable to an arbitrary zeta potential. By solving the Cauchy momentum equation of power-law fluids, the velocity profile across the microcapillary, the flow rate, the shear stress distribution and dynamic viscosity of electroosmotic flow of power-law fluids are presented for both low/high zeta potential, different flow behavior index and dimensionless electrokinetic width. The flow rate and average velocity are obviously enhanced for high zeta potential. Because of the shear thinning effects of power-law fluid, the velocity profile gradually changes from parabolic to plug-like shape as the flow behavior index decreases. For shear thinning fluids, the viscosity is greater in the center of the microchannel than that near the channel wall; the reverse is true for the shear thickening fluids. The greater the volumetric rate and average velocity, the greater the dimensionless electrokinetic width and the flow behavior index. It is noted that, besides the dimensionless electrokinetic width, the zeta potential and flow behavior index shows a significant influence on the flow in microcapillary. This theoretical investigation can serve as a guide for the design and optimization of microfluidic devices.

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