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生物芯片微通道周期性电渗流特性

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摘要 以双电层的Poisson-Boltzmann方程和黏性不可压缩流体运动的Navier-Stokes方程为基础，提出二维均匀微通道周期电渗流的解析解. 分析结果表明，周期电渗流速度大小不但与双电层特性和外电场有关，而且与流动雷诺数(Re = \omega h^2/\nu)密切相关. 随雷诺数增加，双电层滑移速度下降. 当离开固壁距离增加时，双电层以外区域流动速度快速衰减，速度滞后相位角明显增加. 研究发现在微通道有波浪状速度剖面. 给出在低雷诺数时的周期电渗流渐近解，它的速度振幅与定常电渗流速度相同，并具有柱栓式速度分布形态. 还得到在微通道宽对双电层厚的比值(\kappa h)很小时，Debye-H\"{u}ckel近似的周期电渗流解，并与解析解进行分析比较 微通道，双电层，周期电渗流，雷诺数

关键词 微通道,双电层,周期电渗流,雷诺数

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Flow behavior of periodical electroosmosis in microchannel for biochips

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Abstract

This paper presents an analytical solution for periodical electroosmotic flows in a two-dimensional uniform microchannel based on Poisson-Boltzmann equations for electric double layer (EDL) and Navier-Stokes equation for incompressible viscous fluid. Analytical results indicate that the velocities of periodical electroosmosis strongly depend on Reynolds number $Re = \omega h^2 / \nu $, as well as on EDL properties and the applied electric field. The slip velocity of EDL decreases as the Reynolds number increases. The electroosmosis velocity outside the EDL rapidly decreases, and the lag phase angle of the velocity increases as the distance away from the channel wall increases. A wave-like velocity profile across the microchannel is found. An asymptotic solution for low Reynolds number is also given in this paper. Periodical electroosmosis with low Reynolds has the same velocity amplitude and a plug-like velocity profile as that of the steady electroosmosis. Debye-H\"{u}ckel approximate solution of the periodical electroosmosis in cases of small κh, the ratio of the microchannel width to EDL thickness, is obtained and compared with the analytical solution.

Key words electric double layer periodical electroosmosis microchannel Reynolds number

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