Effect of Conductivity and Viscosity in the Velocity Characteristics of a Fluid Flow Induced By Nonuniform AC Electric Field in Electrolytes on Microelectrodes

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Abstract

Electrokinetic transport of fluids has been investigated both experimentally and numerically due to its various applications in microfluidic devices [1-5]. These devices offer the advantage of transporting fluids or particles to specific locations without the aid of mechanical components. The device by Green et al consists of a symmetric arrangement of CPE subjected to an AC potential [6-8]. The electrosmotic velocity shows a maxima as the frequency of the applied potential varies from 1 Hz to 10 kHz which is within the approximation of a planar structure for electric double layer. However, it is plausible that at higher frequencies interplay of various forces as well as the finite size of the ions would lead to a deviation from the simplification adopted in most theoretical models. In the present study, the frequency range was extended to 80 kHz and a second peak, however smaller by an order of magnitude, was observed at higher frequencies indicating deviation from the linear model. The effect of changes in conductivity and viscosity of the electrolyte was also studied. Polarization of the electrodes attracts ions of opposite charge forming a thin mobile layer of ions on the surface. The system can be modeled as a linear RC circuit in series. The system was solved in two steps, one for the electric potential using the electric current interface and secondly for the fluid flow using the laminar flow interface. The electrolyte KCl was taken to have a conductivity of 2.1 × 10-3 S/m and viscosity of .001 Pa-s [6]. The schematic of the system is shown in Figure 1. Fluid velocities of the order of 50μms-1 were observed. The plot of the velocity magnitude as a function of frequency of the applied potential is shown in Figure 2a. A second peak in the velocity spectrum occurring at higher frequencies is clearly visible in Figure 2b beyond 8.5 μm from the electrode edge (x = 21 μm). It is also to be noted that the frequency dependence of the peak velocity at the two peaks is opposite in nature. The graphs in Figure 3 and Figure 4 show the dependence of peak velocity on conductivity and viscosity of medium respectively. The patterns indicate dependence of peak frequency on the conductivity of the system in the chosen frequency range. A symmetric CPE geometry filled with an electrolyte was subjected to an alternating potential. Presence of the second peak indicates deviation from the linear model at higher frequencies. A second peak is observed in the velocity spectrum at a higher frequency even with changes in the conductivity of the electrolyte. The observations show a dispersive behavior of the peak velocity with respect to conductivity but not with viscosity.

Reference

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Figures used in the abstract

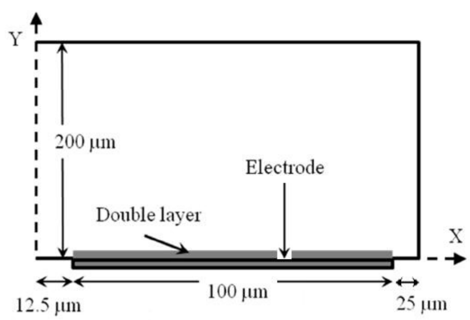

Figure 1: The schematic of the system.

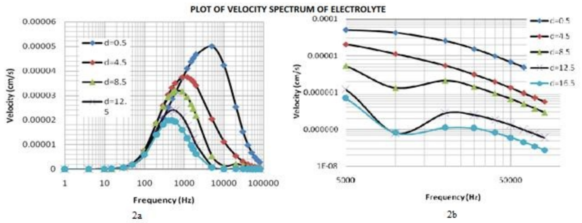

Figure 2: Velocities are taken at distances of 0.5, 4.5, 8.5, 12.5 and 16.5 μm (curves from top to bottom) from the edge of electrode along the x-axis (2a). Log-log plot of the velocity spectrum in the high frequency range clearly shows a second peak (2b).

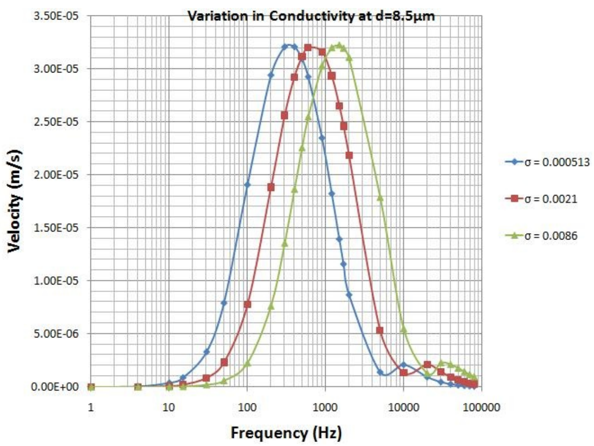

Figure 3: The figure shows dependence of peak velocity on conductivity of the medium.

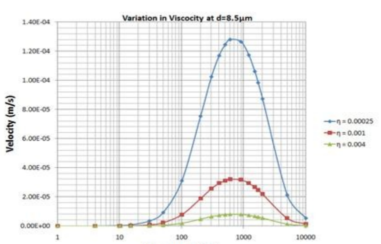

Figure 4: The figure shows dependence of peak velocity on viscosity of the medium.