Strong Electric Field Electroosmosis: Physical Principles and Measurements in the Strongly Nonlinear Regime

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ABSTRACT Electroosmosis is the motion of an electrically neutral fluid under the influence of an electric field due to interface breaking of local electrical neutrality. We analyzed a simple system in which there are non-linear effects present, related to the bulk electrolyte depletion caused by the accumulation of ions at the electrodes (essentially due to electrolysis). This system was studied in the regime of a strong electric field and a low electrolyte concentration. We placed 2 electrodes and a layer of potato starch that serves as a porous material inside a syringe filled with tap water. We connected the syringe to a capillary tube. The system was connected to a battery. We measured the intensity of the electric current and the height of the liquid in the capillary tube in two different situations: a vertical capillary (corresponding to a small time scale) and a virtually horizontal capillary (corresponding to a large time scale). The initial apparent electroosmotic velocities have the same value for different positions of the capillary (0,24 mm/s). For the almost horizontal capillary, the large-time limit of the velocity is 0,56 mm/s – significantly larger than the initial value. These results were consistent with an initial zeta potential of roughly 30mV and a final zeta potential of roughly 70 mV. Long time scale effects are significant, causing the zeta potential to vary. This can lead to electroosmosis in systems where it was not previously expected; for example, in the interstitial fluid near the tight junctions of the epidermis.

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