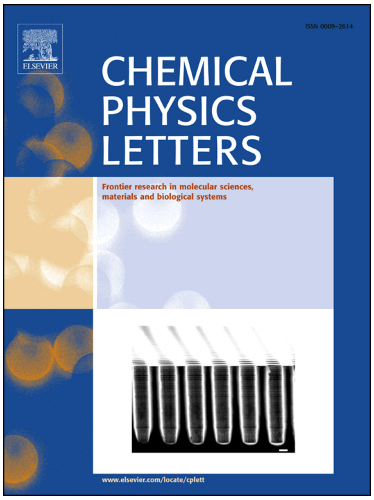

Power-law electrokinetic behavior as a direct probe of effective surface viscosity

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Power-law electrokinetic behavior as a direct probe of effective surface viscosity

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Abstract

An exact solution to the Poisson-Boltzmann and Stokes equations is derived to describe the electric double layer with inhomogeneous dielectric and viscosity profiles in a lateral electric field. In the limit of strongly charged surfaces and low salinity, the electrokinetic flow magnitude follows a power law as a function of surface charge density. Remarkably, the power-law exponent is determined by the interfacial dielectric constant and viscosity, the latter of which has eluded experimental determination. Our approach provides a novel method to extract the effective interfacial viscosity from standard electrokinetic experiments. We find good agreement between our theory and experimental data.

Keywords: Electrokinetics, interfacial slip, liquid-solid interface, electric double layer

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Introduction. — Electro-osmosis is the motion of an electrolyte solution induced by an electric field along a surface [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12], whereas electrophoresis is the electric-field-induced motion of a colloid suspended in an electrolyte [1, 2, 3, 13, 14, 15]. These electrokinetic effects play important roles in industry and bio-systems [16, 17, 18]. Originating in the nanometer-wide electric double layer, both effects depend sensitively on the structure and the dynamic properties of this interfacial layer at a charged surface. Simulation studies demonstrate that the surface layer exhibits an increased viscosity at hydrophilic surfaces [19], in agreement with early theories used to explain electrokinetic experiments [3]. At hydrophobic surfaces,

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