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

Yuki Uematsu<sup>a,b,\*</sup>, Roland R. Netz<sup>b</sup>, Douwe Jan Bonthuis<sup>b</sup>

<sup>a</sup>*Department of Chemistry, Kyushu University, Fukuoka 819-0395, Japan*

<sup>b</sup>*Fachbereich Physik, Freie Universität Berlin, 14195 Berlin, Germany*

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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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\*Corresponding author

Email address: uematsu@chem.kyushu-univ.jp (Yuki Uematsu)

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