

Abstract Submitted
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Microscopic Electrohydrodynamics of DNA electrophoresis¹

ALEKSEI AKSIMENTIEV, BINQUAN LUAN, Department of Physics, University of Illinois at Urbana-Champaign — Gel electrophoresis is currently the most successful yet costly method to sequence DNA. Electrophoresis of DNA through solid-state nanopores holds promise for reducing the costs and making personal genomics a reality. The underlying physics of DNA electrophoresis, however, remains controversial. Theoretical models of this process often invoke the notion of the effective charge of a DNA molecule q_{eff} to account for the reduced electric force on DNA in an external field E , i.e. $F = q_{\text{eff}}E$. However, experimental estimates of q_{eff} can differ from each other by as much as ten times. To clarify the physical origin of the reduction of an electric force on DNA in electrophoresis, we investigated this process through extensive all-atom molecular dynamics simulations. Our results demonstrate that the effective screening of the DNA charge arises from the hydrodynamic drag of the electroosmotic flow, not from the counterion condensation. We show that the effective driving force F of an applied electric field E in a nanopore obeys the same law as in a bulk electrolyte: $F = \xi\mu E$. Here, ξ and μ are, respectively, the friction coefficient and electrophoretic mobility of DNA that depend on the surface properties of a nanopore, such as its roughness. Based on the above law, a method for determining the effective driving force is suggested that does not require a direct force measurement.

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