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Nonlinear electrokinetic transport in networks of microscale and nanoscale pores SHIMA ALIZADEH, MATHIAS B. ANDERSEN, ALI MANI, Department of Mechanical Engineering, Stanford University — The objective of this study is to develop the understanding of nonlinear electrohydrodynamic effects in a wide range of systems including lab-on-a-chip systems, electroosmotic pumps, and, in general, porous media with random or fabricated pore morphology. We present a continuum model in which these systems are described as massive networks of long and thin pores. The thickness of the pores can vary from nanoscale to microscale, corresponding to the highly overlapped electric double layers (EDL) to the thin double layer limit. Within each pore the transport in the wall-normal direction is assumed to be in equilibrium leading to a reduced order model for the axial transport of species in the form of a transient one-dimensional partial differential equation (PDE). PDEs from different pores are coupled through boundary conditions at the pore intersections by proper implementation of the conservation laws. We show that this model can capture important nonlinear dynamics, which are typically ignored in homogenized models. Specifically, our model captures concentration polarization shocks and flow recirculation zones respectively formed when micropores and nanopores are connected in series and in parallel. We present a comparison between our model and recent experiments in microfluidics, and will discuss applications in porous media modeling for energy storage and water purification systems.

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