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A multiscale analysis of electrokinetic transport in porous media[1]

SHIMA ALIZADEH, Stanford University, MARTIN Z. BAZANT, Massachusetts Institute of Technology, ALI MANI, Stanford University — A wide range of applications, including electrochemical energy conversion, deionization, and lab-on-a-chip devices involve transport phenomena in porous media or networks of microchannels. Transport in such systems is governed by electrokinetic phenomena describing the coupling between fluid flow, ion transport, and electrostatic effects. In these systems, surface conduction through electric double layers (EDLs) can lead to nonlinear dynamics such as deionization shocks. Additionally, when pore size varies randomly in space, electrokinetic effects can generate internally induced flow loops, leading to enhanced mixing and increased effective diffusivity. We have developed an efficient computational model that can accurately capture the aforementioned nonlinearities inside porous media by modeling a porous medium as a network of pores each governed by one-dimensional partial differential equations. Using this model, we demonstrate simulations of massive networks of pores, and discuss the impact of pore size variability and random connectivity on macroscopic behavior and transport rates in porous media.

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