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Ion transport and rectification in a charged nanoscale cone[1]
FAN YANG, Princeton University, LI ZHANG, QIAN MAO, Tsinghua University, HOWARD STONE, Princeton University — The possibility of rectification for ion transport in nanofluidic systems offers a potential route for developing a nanofluidic diode that mimics a semiconductor diode or captures some features of a biological ion channel. The rectification phenomenon, in which a solution would be enriched in one ion, results from asymmetric effects in ionic transport that can be realized by discontinuities in surface charge, concentration differences across a pore, or an asymmetric pore shape such as a cone. In this paper, we focus on the latter two effects and seek to capture the rectification effect in simple terms with a non-dimensional model representative of the many systems studied to date. Specifically, we analyze the rectification phenomenon in a charged nanoscale cone with a concentration difference and/or an electrical potential difference across the pore. Based on the Poisson-Nernst-Planck model and the assumption of one-dimensional transport, we derive a model based on two coupled ordinary differential equations to determine significant parameters such as ionic current. We identify several dimensionless parameters that have not been recognized previously and study the influence of the dimensionless parameters on the rectification.

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