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Shock Electrodialysis

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Salt transport in bulk electrolytes occurs by electro-diffusion and convection, but in microfluidic devices and porous media, electric double layer phenomena on the internal surfaces also contribute to ionic fluxes. The nonlinear coupling of bulk and interfacial transport leads to some surprising new phenomena, such as over-limiting current (faster than diffusion) sustained by a deionization shock wave, which removes salt by surface conduction (electro-migration) and surface convection (electro-osmotic flow). Propagating ion concentration shocks in glass microchannels were discovered at Stanford by Mani, Zangle & Santiago (2009), and this talk will describe extensions and applications of this phenomenon in weakly charged porous media, or "leaky membranes". Theoretical and experimental results for scalable and continuous water purification by "shock electrodialysis" will be presented. Shock ED can achieve 99.99% salt removal with high water recovery (~80%), while also performing separation, filtration and disinfection of the feedwater. The energy efficiency (~0.5%) and current efficiency (~60%) of the first prototype are expected to improve significantly with system optimization, according to theory. Applications of shock ED range from point-of-use water purification or recycling in gravity-fed systems, to large-scale municipal or industrial water treatment plants. The talk will also touch upon other applications of deionization shocks in porous media, such as separators or composite electrodes for rechargeable metal batteries.

Biography

Martin Z. Bazant is the Edwin G. Roos (1944) Professor of Chemical Engineering and Mathematics at the Massachusetts Institute of Technology. He earned a PhD in condensed matter physics from Harvard University and joined the MIT faculty in Mathematics in 1998, where he has made fundamental contributions to electrochemistry, electrokinetics, and fluid mechanics. In 2009, he joined Chemical Engineering and started an experimental laboratory. He received the Alexander Kuznetsov Prize in Theoretical Electrochemistry in 2015 from the International Society of Electrochemistry. Other honors include the Paris Sciences Chair (ESPCI), Brilliant Ten (Popular Science Magazine), the Lighthill Lecture (British Applied Math), the Winchell Lecture (Purdue), and the Corrsin Lecture (Johns Hopkins). He serves on the editorial board of *SIAM Journal of Applied Mathematics* and *Scientific Reports* (Nature Publishing Group) and is the Chief Scientific Advisor for Saint Gobain Ceramics and Plastics, Northboro R&D Center.