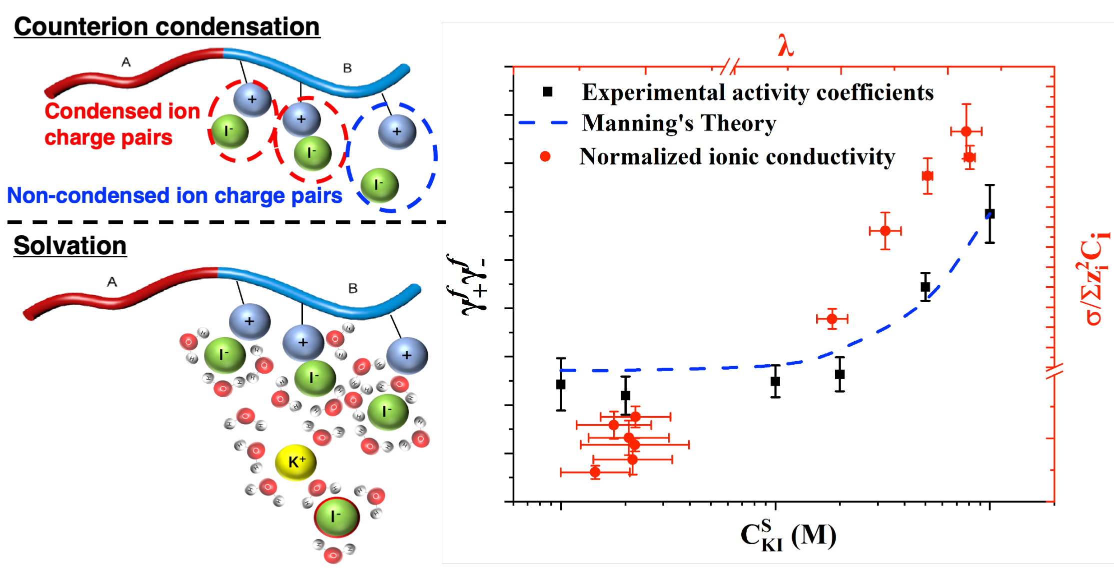
Electrochemistry with Model Thin Film Polymer Electrolytes

Polymer electrolyte membranes and electrode binders are important materials to the performance and efficiency of numerous electrochemical processes in separations, electrolysis, and energy storage and conversion. Part 1 of this talk presents the impetus behind the re-emergence of high-temperature polymer electrolyte membrane (HT-PEM) fuel cells. New polymer architectures based upon polycation-acid anion interactions have resulted in superior HT-PEMs in terms of ionic conductivity and stability over the classic phosphoric acid imbibed polybenzimidazole (PBI). Despite the advent of more functional membranes, gas reactant transport and reaction kinetic limitations in electrode layers still stymie the power density of HT-PEM fuel cells. To address these problems, our lab has leveraged high-throughput experimental methods to study the electrochemical properties of thin film, high-temperature polymer electrolytes. Part 2 of the talk presents our work on probing the ionic activity coefficients in thin film polymer electrolytes interfaced with aqueous solutions using molecular dynamics simulations and advanced metrology (e.g., environmental GI-SAXS, QCM, and thin film ionic conductivity measurements on interdigitated electrodes). The ionic activity coefficients have a profound impact on equilibrium ion-partitioning behavior and selective removal of ions from liquids in electrochemical separations. They also affect the rate of ion transport in polymer electrolytes. Interestingly, Manning's Theory of counterion condensation is shown to be an effective predictor of the activity coefficients in block copolymer electrolytes without any adjustable parameters (Figure below). Despite the utility of Manning's Theory, MD simulations reveal that the existence of two distinct counterion types, condensed and non-condensed, is unlikely and that solvation is the more important descriptor for understanding ionic dissociation, activity, and conductivity in polymer electrolytes.



Bio

Chris is an Assistant Professor in Chemical Engineering at Louisiana State University (LSU) in Baton Rouge. A native of the Chicago area, he earned his BS in Chemical Engineering from the University of Illinois at Urbana-Champaign followed by his PhD in Chemical Engineering at the Illinois Institute of Technology and a Postdoctoral Fellowship at the University of Chicago. His research interests lie at the intersection of electrochemical engineering and polymer science.