Hydrodynamic instability in concentration polarization at ion-exchange electrodialysis membrane

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One dimensional steady state passage of the electric current from an aqueous electrolyte solution into a charge selective (perm-selective) solid, such as an ion exchange electrodialysis membrane or metal electrode, is hydro-dynamically unstable, yielding over-limiting conductance in concentration polarization. For a long time this instability was attributed to electro-convection related to the extended space charge which forms at the outer edge of the electric double layer at the limiting current. For a perfectly perm-selective membrane with infinite conductivity, this mechanism was the only possible option. Recently, it was shown that a non-perfectly perm-selective membrane, or a perfectly perm-selective one with finite conductivity, additional electro-convective instability mechanisms were possible, non-related to the extended space charge. These studies focused on electro-convective instability mechanisms because it was recognized that for most practical situations, gravitational mechanism related to concentration polarization induced density stratification in the interfacial diffusion layer could not yield instability. Lately, an interesting possibility was discovered of a Joule heating related instability expected to occur in thick diffusion layers with gravitationally stable density stratification. In this presentation, we review the possible hydrodynamic instability mechanisms in concentration polarization in their relation to over-limiting conductance in electrodialysis.

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