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Ion concentration polarization for separation of charged species

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Polarization of ion-exchange membranes in a DC electric field leads to the formation of ion-depleted and ion-concentrated zones in the solution layers adjacent to the membranes. The ion-depleted zone is especially interesting owing to a multitude of reaction-transport phenomena associated with its occurrence. Although not apparent immediately, such a zone offers auspicious conditions for controlling the transport of ionic species present in the surrounding solution. To shed light on the working principle of such systems, we analyze the system behavior theoretically with a 2D model based on the Poisson-Nernst-Planck-Navier-Stokes set of equations and confirm its prediction experimentally by conducting a study looking into the behavior of charged chemical species differing primarily in their charge number. Specifically, we show that the ion-depleted zone works as a nonmechanical filter that displays ion selectivity if the separated ions differ in their electrophoretic mobility, affected mainly by the charge number and diffusion coefficient. This selectivity is given by differing electrophoretic forces acting on individual ionic species. The talk will focus on elucidating the fundamental principles governing the studied system and show its use for pseudo-continuous separation of charged dyes as a proof-of-principle application.