Entrance effects in concentration-gradient-driven flow through an ultrathin porous membrane

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Abstract

Transport of liquid mixtures through porous membranes is central to processes such as desalination and chemical separations, with ultrathin membranes made from novel 2D nanomaterials showing exceptional promise. This presentation discusses the derivation of general equations for the solution and solute fluxes through a circular pore in an ultrathin membrane induced by a solute concentration gradient within the framework of continuum hydrodynamics. The equations are shown to accurately capture the fluid fluxes measured in finite-element numerical simulations for weak solute–membrane interactions. Scaling laws are derived for these fluxes as a function of the pore size and the strength and range of solute–membrane interactions. These scaling relationships differ markedly from those for concentration-gradient-driven flow through a long cylindrical pore and have broad implications for transport of liquid mixtures through membranes with a thickness on the order of the characteristic pore size. Finally, the effects of deviations from the assumptions of continuum and ideal-solution behavior on these concentration-gradient-driven fluxes are tested using molecular-dynamics simulations.

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