Analytical Models for Osmotically Driven Membrane Processes at Osmotic Equilibrium

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Forward osmosis (FO) is an emerging water treatment technology that has demonstrated a unique ability to handle difficult and complex feed streams (*e.g.*, those found in the desalination of high-salinity brines and wastewater reclamation). In the FO process, an engineered draw solution is used to generate an osmotic pressure difference that drives the flux of water through a semipermeable membrane from the feed solution into the draw solution. Simultaneously, solutes present in the feed solution and the draw solution move down their respective concentration gradients. Understanding the evolution of the water and solute fluxes along the length of the membrane module is vital to determine the optimal operating conditions for an FO process. This study seeks to quantify the effects of water and solute fluxes on the performance of novel FO systems using simple mathematical models. Specifically, because the presence of a water flux renders the governing equations non-linear, it is useful to find solutions that describe the system in appropriate and physically relevant limits. Here, a binary system (*i.e.*, one feed solute and one draw solute) is studied, and the performance of the system is described in terms of the recovery rate, which quantifies the amount of water that moves from the feed solution to the draw solution, and the separation factors, which quantify the amount of the solutes that permeate through the membrane. The influence of membrane properties (*e.g.*, the relative magnitude of the permeability of water to the permeability of solutes) and operating conditions (*e.g.*, the ratio of the initial flow rate of the feed solution to the initial flow rate of the draw solution) on the percent recovery and the separation factors will be discussed. These models and their solutions will ultimately allow for the prediction of system level performance based on lab scale membrane characterization.