Foundational Framework for Evaluating Performance of Nanofiltration-based Solute-solute Separation

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Abstract:

Precise solute-solute separation using nanofiltration (NF) membranes has recently emerged to become one of the frontiers for membrane-based separation due to the increasing demand for selective separation in resource recovery and extraction from aqueous feed streams. Example applications of selective separation include the extraction of lithium from brine, recovery of nutrients from wastewater, and recycling of acid or base from process streams. Most existing studies focused on fabricating novel NF membranes for selective solute-solute separation, while limited recent studies have also investigated the fundamental mechanisms to enhance solute-solute selectivity. Nonetheless, certain basic but critical questions regarding evaluating the performance of process and membranes remain to be unanswered. This presentation aims to address these questions and provide new insights to establishing the theoretical framework of quantifying solute-solute selectivity in NF-based precise separation. Using lithium/magnesium (Li/Mg) separation as an illustrative example, we will show that the existing evaluation framework based on solute-solute selectivity is inconsistent with the goal of solute-solute separation. We also perform module-scale analysis to reveal behavior of ion transport in NF-based Li/Mg separation and propose two important tradeoffs for performance and membrane materials.