# Chemical Engineering Doctoral Defense

## Investigation of water permeation through molecular sieve particles in thin film nanocomposite membranes

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## abstract

Incorporation of nanoporous materials into the state-of-the-art polyamide-based thin-film composite membranes to create thin-film nanocomposite (TFN) membranes is a promising strategy to address current desalination challenges such as increased energy–efficiency, perm-selectivity, and resistance to fouling and chlorine. However, in TFN membranes, the actual impact of the nanomaterials on membrane performances is unknown. Commonly, nanomaterials are dispersed in casting solutions during sensitive polyamide interfacial polymerization process. Particle aggregation, non-uniform particle dispersion, and possible particle leaching from the membranes are challenges with the conventional TFN synthesis method. Determining the intrinsic properties of filler particles, the polymer, and the particle/polymer interface and their contributions to water transport are critical to the investigation of TFN membranes. TFN membranes exhibit great promise for water permeance enhancement and the addition of new features such a chlorine resistance and fouling resistance. However, a meta-analysis of nanoporous material (zeolites, MOFs, and graphene-based materials) addition in polyamide-based osmotic TFN membranes showed no uniform performance result. An experimental study of TFN membranes provides an understanding of the effect of nanoporous particles in water transport. Non-porous (pore-closed) and nanoporous (pore-opened) zeolite particles at different crystal sizes were incorporated into membranes and studied as a filler. Membranes with pore-opened particles showed higher water permeance compared to corresponding membranes with pore-closed particles. Model membrane designs were developed as an additional method to probe the individual contributions of the role of nanoporous materials, interface with polymer, and polymer, in the membrane water transport. Nanoporous particle incorporation into TFN membranes slightly enhanced the water permeance compared to the incorporation of nonporous particles to TFN membranes. Analysis of these membranes with the resistance in parallel model isolates the water transport pathways in TFN membranes. This analysis yields that possible water permeance through the zeolite pores was insignificant compared to the water permeance through the particle/polymer interface and the polymer. Therefore, the experimental results do not support the hypothesis that nanoporous zeolites provide a preferential water pathway through the interior cage of the zeolite. However, the complexity of the interfacial polymerization reaction requires more research to fully understand the role of nanoporous particles on the water permeance.

October 25, 2018; 11 AM; GWC 137A