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Comparison of 2D and 3D materials on membrane modification for improved pressure retarded osmosis (PRO) process

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Abstract

Pressure retarded osmosis (PRO) is a sustainable process that convert Gibbs free energy to osmotic energy by mixing two solutions of different salinities. The main challenges in the design of PRO membranes are obtaining a membrane with high water permeability and low salt permeability but also very high mechanical strength because the PRO process involves high pressure on the draw solution. Commercially available RO membranes with potential utility in a PRO system exhibit a high salt rejection rate but low water permeability and mechanical stability. Surface modification is a promising strategy for tuning the fundamental properties of the membranes (e.g. hydrophilicity, surface charge and thickness) that can improve the filtration performance of the membranes. The coating layer can also improve the mechanical stability of the membranes. Therefore, in this work, various types of modification materials were applied to the commercial available RO membranes to enhance their performance.

With the assistance of hydrophilic materials (e.g. polydopamine – PDA), filtration performance of the membranes can be increased through membrane modification by 2D materials with high charge intensities (e.g. polyelectrolytes and graphene oxides) and by 3D mesoporous materials (e.g. zeolites), which increases the thickness of the membrane that can be beneficial in mechanically reinforcing the membrane. In this

work, we modified commercial RO membrane with PDA, polyelectrolytes, graphene oxide and zeolites (ZSM-5). Improved filtration performance (increased water permeability and maintained salt permeability) of the modified membrane was observed. Tensile tests showed enhanced mechanical strength of the modified membranes, especially following 3D zeolites modification (up to 35 % of higher tensile strain was reported). Interestingly, a lower concentration of PDA (2 mg/mL) and zeolites resulted in higher mechanical strength of the modified membranes. Such results were likely due to a more homogenous coating layer when a low modifier concentration was applied. The thin and uniform layer can better absorb energy when membranes are under high pressure.