Surface Engineering to Reduce Membrane Fouling

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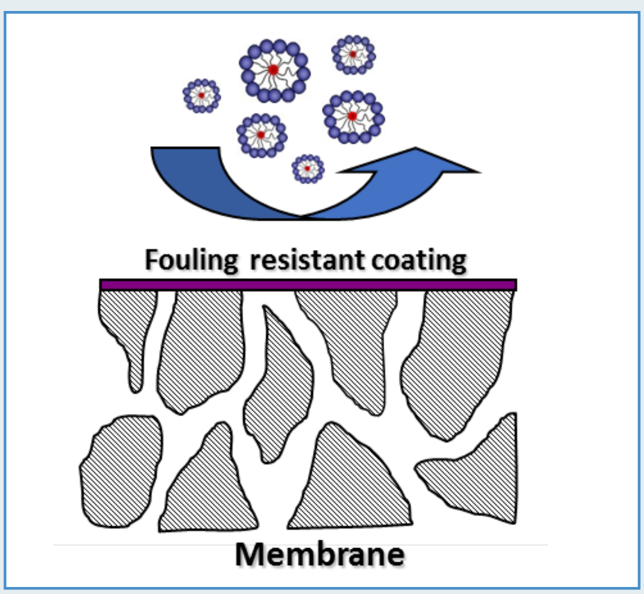
Motivation

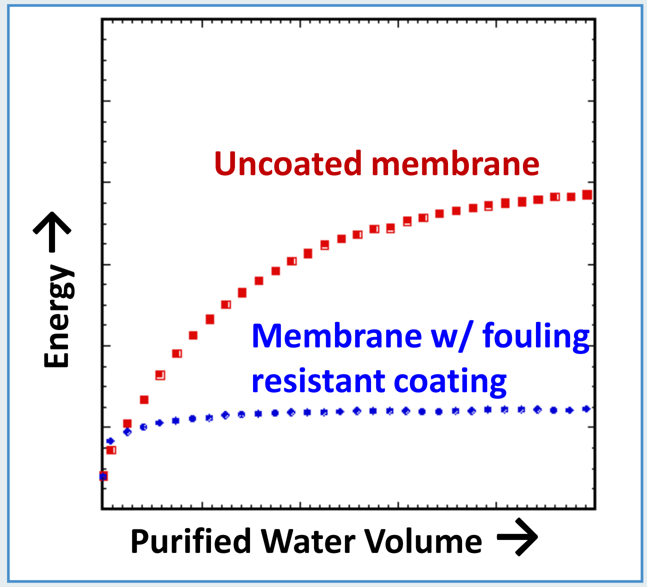
Fouling is a pervasive problem affecting virtually all membrane-based water treatment systems. As clean water passes through a membrane, rejected contaminants tend to plug pores and accumulate on the membrane surface. To maintain a constant rate of clean water production, the pressure of the feed water must be increased, resulting in greater energy expenditure (right). In large scale systems, fouling also contributes to increased costs of chemical or physical cleaning, increased downtime, and shortened membrane lifetime.

Technological Challenges

Most porous water purification membranes are comprised of hydrophobic polymeric materials. Hydrophobic polymers are used because they tend to be robust, relatively inexpensive, and compatible with the casting techniques used to form the porous membrane structure. However, many hydrophobic water contaminants, such as oils, grease, and organic matter, tend to readily adhere to the membrane surface. To reduce the adhesion of these foulants, we have engineered thin, conformal coatings that transform the membrane surface from a hydrophobic surface to a hydrophilic surface. Water molecules tend to strongly associate with the hydrophilic surface, promoting water passage through the membrane pores and forming a buffer layer between the membrane surface and hydrophobic feed water contaminants (below).



Application of a thin hydrophilic coating reduces the adhesion of hydrophobic foulants to the membrane.



Polydopamine-coated ultrafiltration membranes use less energy to purify oily wastewater than uncoated membranes

Research

Dopamine, a small catechol amine molecule, oxidatively polymerizes to polydopamine in alkaline aqueous buffer. When in contact with a membrane, this polymerization results in the formation of a thin, conformal, hydrophilic polydopamine coating on the membrane surface. Polysulfone ultrafiltration membranes coated with polydopamine required approximately 3x less energy to purify water contaminated with emulsified oil than otherwise identical uncoated membranes (above).

Polydopamine-coated ultrafiltration and reverse osmosis membranes were employed in pilot-scale cleanup of oily wastewater from hydraulic fracturing operations in Texas. Coated ultrafiltration membranes exhibited a higher flux than uncoated membranes, and coated reverse osmosis membranes exhibited greater salt rejection than uncoated membranes. The polydopamine coating was easily applied *in situ* to all wetted parts inside the membrane modules.

References

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- B. D. McCloskey, et al. *J. Membr. Sci.* 413-414 (2012) 82.

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