Polymer Membranes for Water Purification

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Abstract: Polymer membranes will be critically important in addressing urgent global needs in the 21st century for reliable, sustainable, efficient access to clean energy and clean water. This presentation will focus on recent advances and applications of polymer membranes for water purification.

Polymer membrane-based desalination has been recognized as an energy efficient, low environmental impact route to produce clean water for a variety of applications. Additionally, ultrafiltration and microfiltration of aqueous streams have become important unit operations in many industries, including the water purification and wastewater purification industries. This presentation focuses on 2 new classes of polymers to attack critical problems in membrane-based water purification: (1) chlorine-tolerant desalination membranes and (2) fouling-resistant membrane nanolayers based on polydopamine.

Commercially available reverse osmosis membranes are prepared mainly from aromatic polyamides (PA). However, PA membranes suffer from poor resistance to continual exposure to oxidizing agents such as chlorine. Chlorine is the most widely used oxidizing biocide in water treatment because it is inexpensive and highly effective when present in water at levels of a few ppm. Disinfection of feed water to membrane desalination units is required to prevent biofilm growth on the membranes, which significantly degrades their performance. However, PA membranes cannot tolerate continuous exposure to water containing more than a few ppb of chlorine. This presentation discusses results from a systematic study of the desalination properties of a new family of highly chlorine tolerant, sulfonated polysulfones. These polymers are prepared via a novel synthesis involving direct copolymerization of non-sulfonated monomers with a disulfonated monomer. By controlling the content of disulfonated monomer in the final polymer, desalination properties, such as water permeability and salt rejection, can be varied over a wide range. A family of materials, based on random copolymers, phase-separated block copolymers, blends, and crosslinked materials may be prepared from these starting blocks to provide a new platform for desalination membranes.

Across many platforms of membranes, fouling mitigation is a major challenge to be addressed to achieve the most energy-efficient, cost-effective membrane filtration processes. Previously, many surface modifications and functionalized polymers were reported to prevent fouling. However, most of these techniques and materials are practically difficult to implement in water purification membranes. We have discovered surface treatment methodologies that can be used to prepare high permeability polymeric membranes from all common water purification membrane classes. These surface-modified membranes have persistent tolerance to fouling by proteins and emulsified oil, two ubiquitous contaminants in a variety of wastewaters. These membranes were prepared by depositing bio-inspired, self-polymerized hydrophilic polydopamine nanolayers on their surfaces. To demonstrate scalability of this modification, the nanolayers were also applied to entire membrane modules. Upon nanolayer deposition, the membranes could be further functionalized using fouling-resistant macromolecules, such as poly(ethylene glycol), to promote improved fouling resistance and, therefore, high membrane flux.