Fouling resistant, high flux membranes through self-organizing polymers

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Water scarcity affects one in three people across the globe. Preserving our water resources and generating fresh, safe water relies on the development of new technologies. Membranes that remove contaminants from water are a key to energy-efficient and effective water treatment. However, their widespread use is limited by low permeability, poor selectivity, and membrane fouling, which occurs due to the adsorption of feed components on the membrane and causes severe flux loss during operation. Rational design of membranes to control key factors such as morphology, surface chemistry, and nanostructure can significantly improve these performance parameters. This presentation focuses on the development of ultrafiltration (UF) membranes with exceptional fouling resistance manufactured without additional processing steps, making use of the self-organizing properties of amphiphilic comb copolymers. Polyacrylonitrile-graft-poly(ethylene oxide) (PAN-g-PEO), an amphiphilic comb copolymer with a hydrophobic polyacrylonitrile (PAN) backbone and hydrophilic poly(ethylene oxide) (PEO) side chains, is used as an additive in the manufacture of novel PAN UF membranes. During casting, the PAN-g-PEO additive segregates to form a PEO brush layer on all membrane surfaces, including internal pores, and resists adsorption of feed components. The resultant membranes resist adsorptive fouling completely, and recover initial performance with a water-only rinse or backwash, eliminating the need for harsh chemical cleanings. They also have significantly higher fluxes compared with membranes cast from only PAN. We have investigated the performance of these membranes in a wide range of applications, including oil well produced water, refinery wastewater, shale gas field wastewater, and membrane bioreactors for treating domestic wastewater. Due to their resistance to adsorptive fouling, these membranes can sustain higher fluxes, require less frequent backwashes, eliminate the need for chemical cleanings, and achieve longer membrane lifetimes, translating to reduced energy consumption during operation and better process economics. This can mean cheaper methods to provide clean water and to protect our water resources.