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Tailoring Polymer Membrane Surface Chemistry via Graft Polymerization to Mitigate Fouling in Biotechnology and Water Purification Applications

Abstract

Applications of membrane processes to water purification are increasing worldwide as they can offer high quality water, flexible design, and scalability. Membrane flux is a critical design criterion, and flux must be maintained during operation. Fouling of membrane surfaces represents a major cause of flux decline, which increases the capital and operating costs, and has been called the “Achilles Heel” of membrane processes. Among the available options to mitigate fouling, an important strategy is to choose a surface chemistry to minimize the affinity between the surface and foulants present in the feed. Choices among commercially available polymers are limited, and the ability to tailor membrane surfaces to specific feeds represents an attractive approach. However, rational design of low fouling membrane surfaces for specific applications remains difficult. As an alternative to rational design, we offer a high-throughput approach to rapidly, efficiently, and reproducibly develop and select optimal polymeric surfaces for particular applications, while also offering the potential to gain understanding for future design of surfaces. The new method adapts a high throughput platform (HTP) the facile modification of poly (ether sulfone) (PES) by graft polymerization. We have combined the HTP with photo- and plasma-induced graft polymerization (PGP) using vinyl monomers (commercially available or synthesized in-house) to produce new polymeric synthetic membrane surfaces. We have employed the HTP-PGP approach to confirm previously reported successful monomers (e.g., poly ethylene glycols) and to develop new anti-fouling surfaces for different feeds of interest to the biotechnology and water treatment communities. This presentation will discuss the method and several new surfaces having optimal surface chemistry. We demonstrate that the HTP-PGP approach to synthesize and screen fouling-resistant surfaces is general, and thus provides the capability to develop surfaces optimized for specific feeds. We also demonstrate the scalability of the HT format using bench scale experiments.