Development of Anti-Fouling, Anti-Microbial Membranes by Chemical Patterning

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Over 1 billion people lack access to clean drinking water. Membranes are a tool that can help provide clean water to these people. However, treatment of impaired waters for beneficial use exposes the membranes to feed waters containing biological and abiotic species, which leads to fouling and loss of membrane productivity over time. Since reduction in flux due to fouling is one of the largest costs associated with membrane processes in water treatment, new coatings that limit fouling would have significant economic and societal impacts. Developing these advanced coatings is the focus of our work.

Prior studies in this area largely have focused on chemical modifications to the membrane surface that either prevent microorganisms from attaching or that kill the microorganisms once they do attach. Based on considerable literature and experience, we know that chemical modification strategies alone can be effective but not sufficient for controlling biofouling. A more recent area of research is nano-patterning the membrane surface. Nature provides many examples where structured features can prevent accumulation of ‘foulant’ materials on the surface (i.e., shark skin, lotus leaves, etc.). Our hypothesis is that combining these two methods (chemical coating and patterning) will yield membrane surfaces that are more effective at biofouling control than either method alone. Membranes coated with dual-mode polymer nanolayers can limit and reverse membrane biofouling by switching reversibly between passive (antifouling) and active (antimicrobial) states. This strategy differs fundamentally from most other surface modification strategies that rely solely on passive control (i.e., using coatings designed only to weaken foulant adhesion) or active control (e.g., adding biocides) and is unique in its use of both chemical coating and patterning to combat biofouling.

In this contribution, we will introduce the methodology used to coat membrane surfaces with dual-mode polymer nanolayers designed to combat biofouling and the methodology used to pattern membrane surfaces. We will explain the chemical switching mechanism and use FTIR to support the reversible switching of the polymer nanolayer between its antifouling and antimicrobial states. We will demonstrate the feasibility of the patterning methodology through AFM. Subsequently, we will test our hypothesis using appropriate model systems (i.e., colloids, proteins, bacteria, etc.).