Environmental Engineering Seminar

The Astani Department of Civil & Environmental Engineering presents

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Place: RRI 101

Rough or Wiggly? Membrane Topology and Morphology for Fouling Control

Reverse osmosis membrane (ROM) systems are applied in wastewater recovery, seawater desalination, landfill water treatment, etc. During filtration, system performance is dramatically affected by membrane fouling which causes a significant decrease in permeate flux as well as an increase in the energy input required. Design and optimization of ROM systems is aimed at reducing membrane fouling by studying the coupling between membrane structure, local flow field, local solute concentration and foulant adsorption patterns. Current studies focus exclusively on oversimplified steady-state models that ignore dynamic coupling between fluid dynamics and transport through the membrane, while membrane design still proceeds through trials and errors. We developed a model that couples the transient Navier-Stokes and advection-diffusion equations, as well as an adsorption/desorption equation for foulant accumulation and validated it against unsteady measurements of permeate flux as well as steady-state spatial fouling patterns. We analytically show that, for a straight channel, a universal scaling relationship exists between the Sherwood and Bejam numbers. We then generalize this result to membranes subject to morphological and/or topological modifications, i.e., whose shape (wiggliness) or surface roughness is altered from the rectangular and flat reference case. We demonstrate that universal scaling behavior can be identified through the definition of a modified Reynolds number, Re*, that accounts for the additional length scales introduced by the membrane modifications, and a membrane performance index, ξ, which represents an aggregate efficiency measure with respect to both clean permeate flux and energy input required to operate the system. Our numerical simulations demonstrate that 'wiggly' membranes outperform 'rough' membranes for smaller values of Re*, while the trend is reversed at higher Re*. The proposed approach can be used to quantitatively investigate, optimize, and guide design of both morphologically and topologically altered membranes under the same framework, while providing insights on physical mechanisms controlling overall system performance.

About the Speaker

In 2005 Dr. Battiato obtained an MS (equiv.) in Environmental Engineering with highest honors at the Politecnico di Milano, Italy. Subsequently, she earned an MS in Engineering Physics (2008) and PhD (2010) in Mechanical & Aerospace Engineering with a specialization in Computational Sciences from University California at San Diego. She held a postdoctoral position at the Max Planck Institute for Dynamics and Self-Organization in, Germany, in the theoretical physics division. Before joining Stanford University's Energy Resources Engineering Department in 2016, she was a faculty member in Mechanical Engineering at Clemson University.

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