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Characterization of Reverse Osmosis Membrane Foulants in Seawater Desalination

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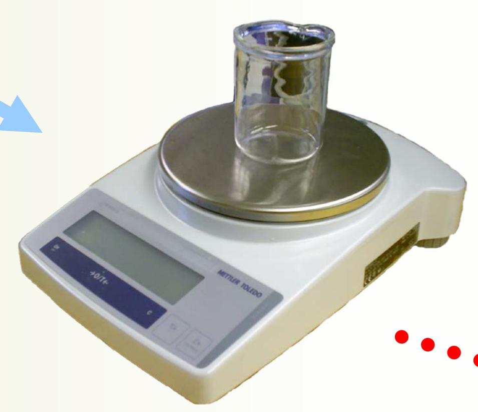
Bench-scale experiments begin at the feed tank. It will be important to find the minimum volume of sample that can provide adequate experimental results.

High seawater salt concentrations mean the reverse osmosis system must be run at pressures around 1000 psi (6900 kPa). A high-pressure pump is utilized.

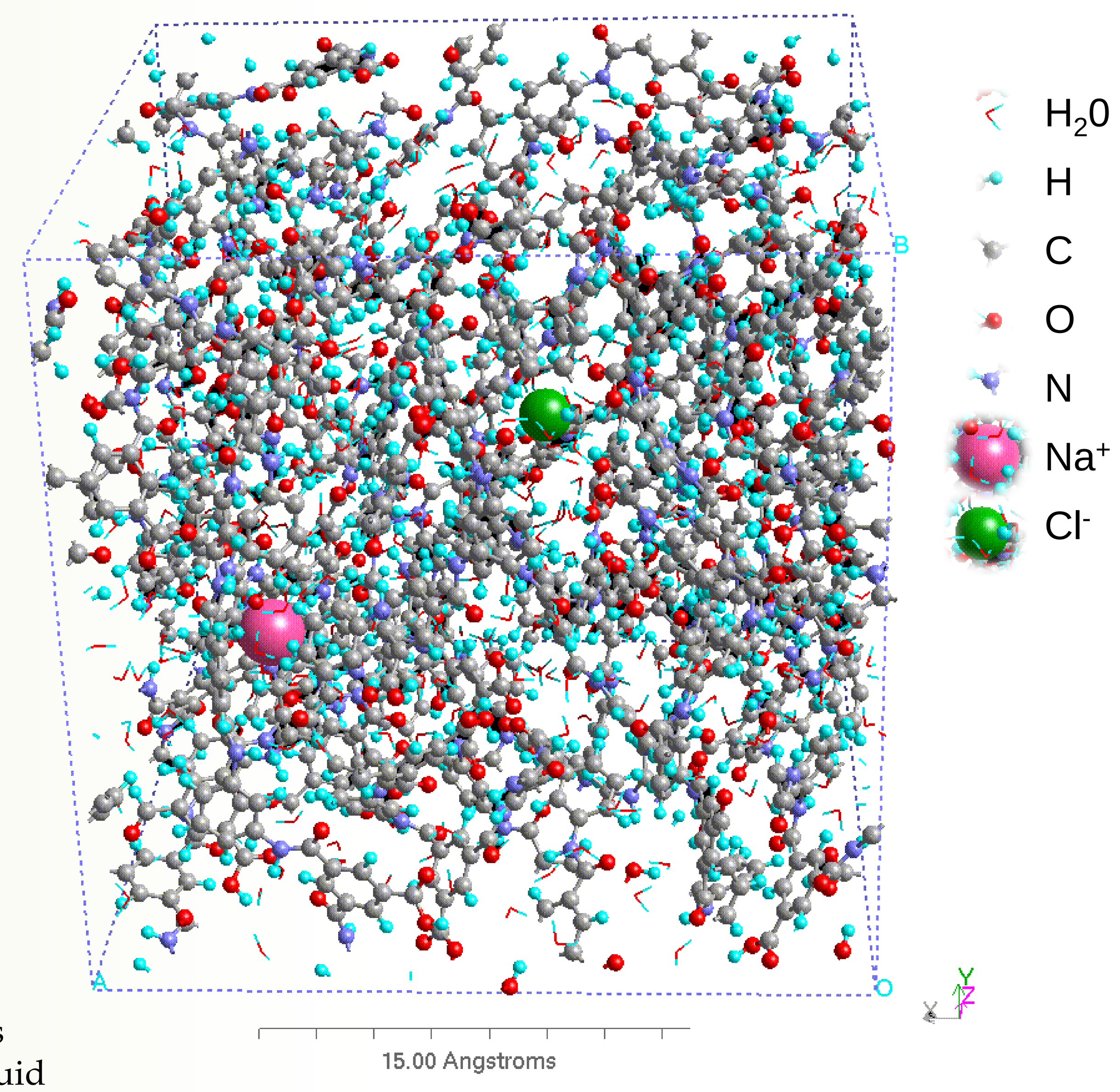
A small membrane coupon (10x15 cm) is tested in this cell. Fluid flow mimics that of full-scale spiral-wound reverse osmosis elements.

Seawater (dark blue arrows) is recycled back to the feed tank. This scheme allows for small sample volumes to be tested, so that water from several locations can be shipped to the laboratory and compared.

Clean, desalinated water (light blue arrow) is collected and weighed to measure flux (membrane productivity) over time.



Automated data acquisition (red dotted line) of flux, pressure, and conductivity provides high-quality data for analysis.



A molecular model (above) of the polyamide membrane active layer represents the surface to which foulants adhere. While the membrane chemical makeup is well characterized, the foulants are not. This project seeks to determine the foulant character and understand how molecular-level interactions affect the full-scale engineered system. *(Image created by Andrey G. Kalinichev, University of Illinois at Urbana-Champaign. Used with permission.)*

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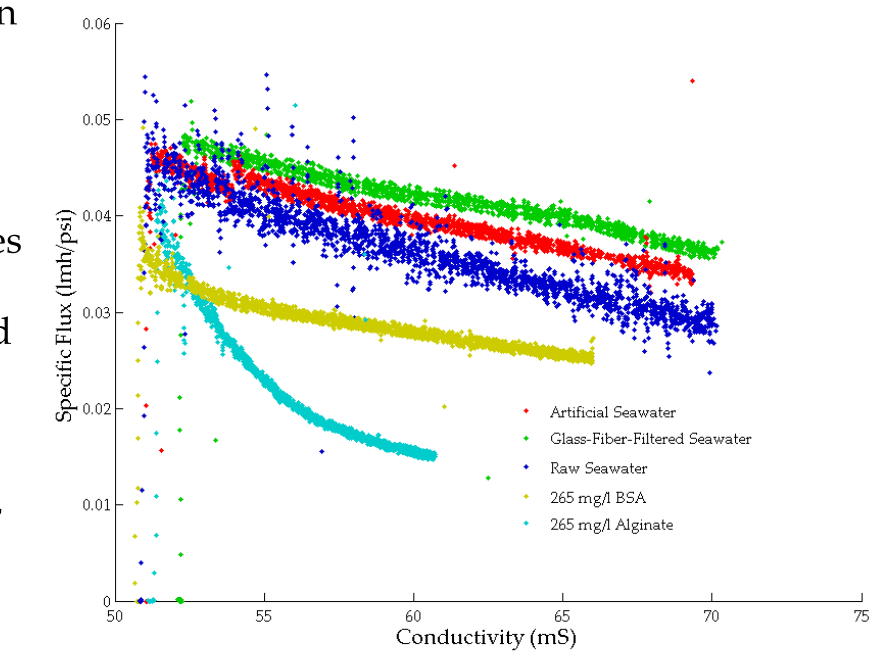
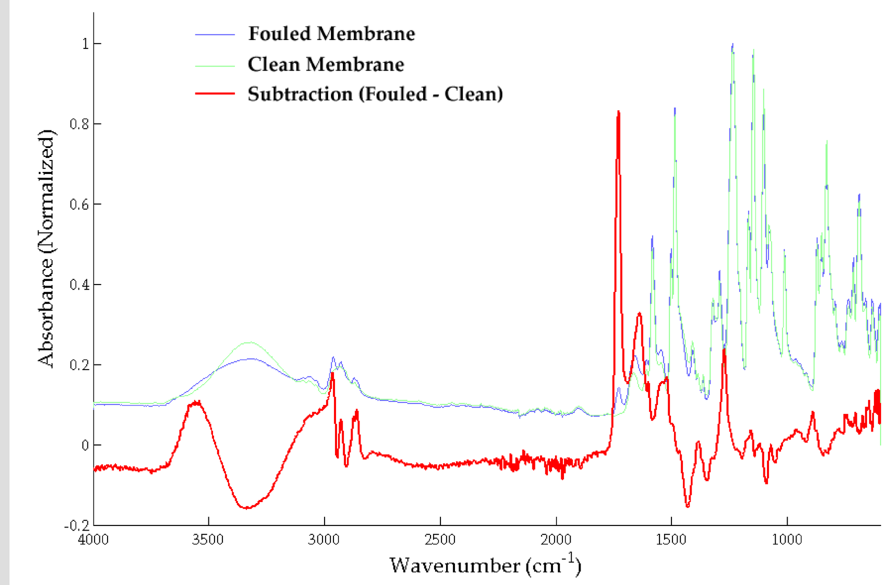
Overview

Seawater reverse osmosis (SWRO) desalination is becoming an attractive treatment technology to provide drinking water in coastal regions. One important limitation to SWRO is fouling of membrane elements from the organic material present in seawater. This project seeks to characterize the organic foulants through bench-scale studies and chemical analyses. Seawater from San Diego, California is being tested, along with well-characterized fouling surrogates (proteins and polysaccharides). Organic material is characterized according to size by high performance size-exclusion chromatography (HPSEC). Foulants on the membrane surface are examined by attenuated total reflectance, Fourier transform infrared spectrometry (ATR-FTIR). Other analytical tools will be used in future experiments. The main impact of this work is that future development of antifouling membranes and fouling control strategies will be aided by a better understanding of the nature of organic foulants in seawater. As advancements are made, SWRO may be a viable drinking water technology leading to water resource sustainability.

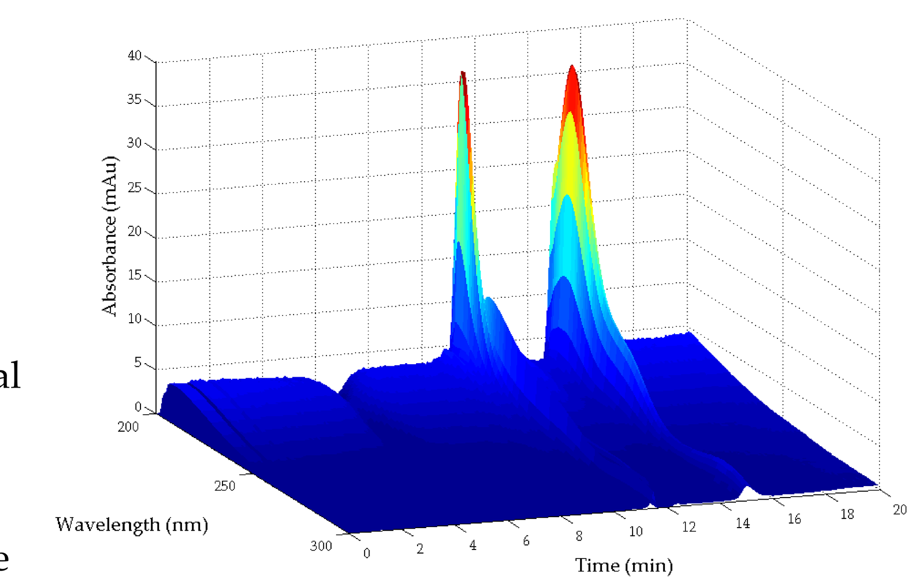
These curves show the decrease in productivity (specific flux) that a reverse osmosis membrane experiences as seawater becomes more and more concentrated (higher conductivity). Particulates in raw seawater, proteins like bovine serum albumin (BSA), and polysaccharides like alginate all foul the membrane, but the way fouling proceeds is different in each case. (Units: lmh = liters per meter squared per hour, psi = pounds per square inch, mS = milliSiemens)





Attenuated total reflectance, Fourier transform infrared spectrometry (ATR-FTIR) is used to study organic functional groups on the membrane. Here, the clean membrane spectrum has been subtracted from the fouled membrane spectrum to reveal a sharp peak at about 1750 wavenumbers. The meaning of this and other peaks is still being investigated.

Data from an advanced high performance size-exclusion chromatography (HPSEC) instrument show that two chemical species are present in a sample. The chemicals have different molecular weights, as evidenced by the separation along the time axis. The chemical makeup is different, also, as indicated by the varying values on the wavelength axis. This information helps to characterize the aqueous membrane foulants.



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