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Transport of water and solutes in reverse osmosis and nanofiltration membranes[1]

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The polyamide active layers of reverse osmosis and nanofiltration membranes used for water purification are real-world examples of nanoscale functional materials: the active layer is only ∼100 nm thick. Because the active layer is formed by a process of interfacial polymerization, the structure and composition of the membrane is highly inhomogeneous and even such basic physical and chemical properties as the atomic density, swelling in water, the distribution of charged species between water and membrane, and the mobility of water and ions, are poorly understood. We are using Rutherford backscattering spectrometry (RBS) to determine the composition, roughness, and thickness of the membrane; reveal the surprisingly high solubility of salt ions in the polymer active layer; analyze the acid-base chemistry of charged functional groups; and determine the degree of polymer cross-linking. Measurements of mass-uptake and adsorption-induced mechanical stress of membranes in humid air enable us to determine the water solubility, specific volume of water, and the mechanical strength of the membrane. Comparisons between these equilibrium data and the permeability of the membrane to water and salts show that the mobility of water molecules in the membrane approaches the mobility of bulk water, and that the rejection of salt ions is accomplished by low mobility, not low solubility. My collaborators in this work are Xijing Zhang, Orlando Coronell, and Prof. Benito Mariñas.

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