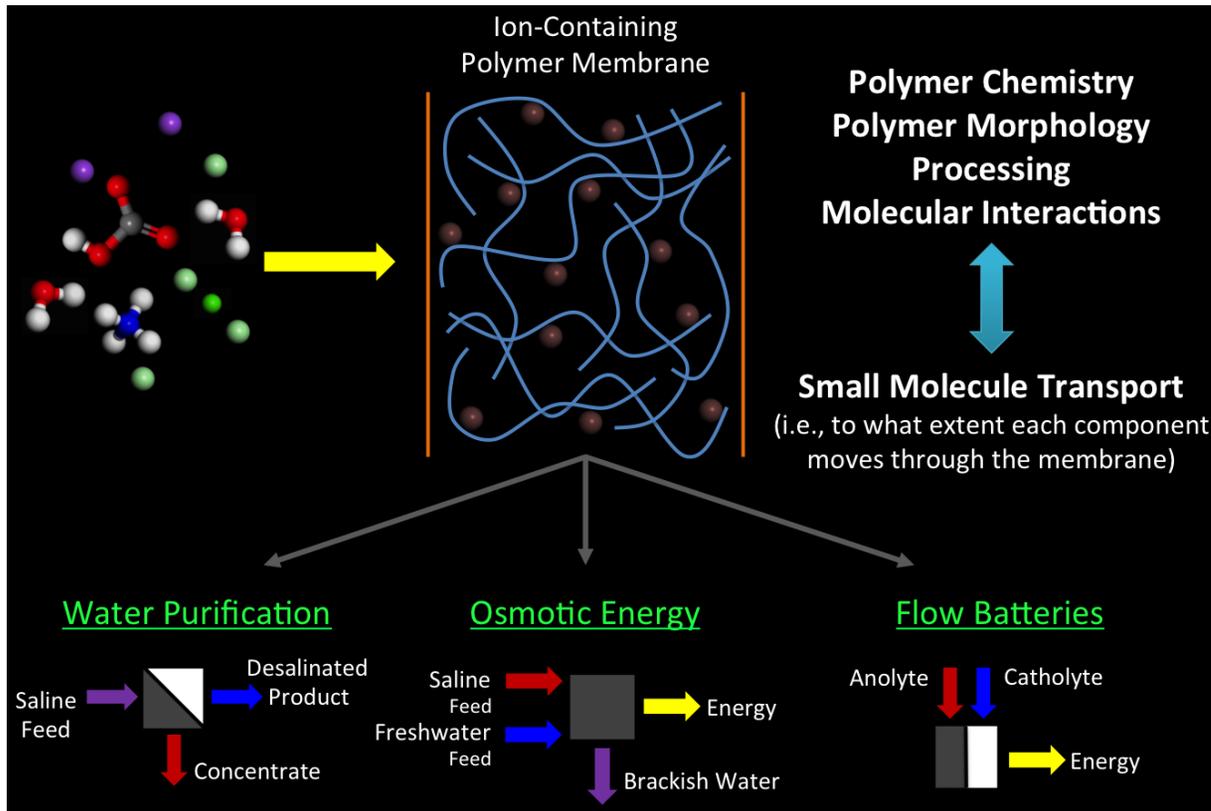


Polymer Engineering for Membrane Separations, Clean Water, and Energy



Providing sustainable supplies of purified water and clean energy is a critical global challenge for the future. Water and energy are inherently linked since clean water often is required to produce energy, and energy is required to purify water. Polymer membranes will play a key role in providing economical and environmentally friendly water purification and energy solutions. Our research focuses on experimental studies aimed at solving fundamental and practical problems related to water and ion transport through polymers that could be used as membranes in a variety of water and energy applications. We seek to rationally tailor and design polymers at the molecular level and process those polymers to engineer advanced membrane materials that will expand access to clean water and enhance the use of renewable energy sources.

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“Improving access to clean water and energy through the design of advanced polymer membrane materials.”



Water Purification for a Thirsty World

According to the United Nations, nearly one fifth of the world's population is believed to live in regions of the world that lack physical access to sufficient amounts of water, and nearly one quarter of the world's population lacks sufficient access to water due to economic constraints. These startling figures will become more severe as water use is increasing at nearly twice the population growth rate. Within the next 10 years, the United Nations predicts that nearly two-thirds of the world's population may find themselves living in a water stressed area. Increasingly saline and contaminated water sources will need to be purified in order to satisfy growing personal, agricultural, and industrial water needs around the world. Membrane-based technologies currently dominate the water desalination market, and the vast majority of membrane processes are performed using polymer-based membranes. Improved membranes are needed to meet the challenges of economically and sustainably purifying increasingly saline and contaminated water sources around the globe, and this need represents an opportunity for polymer science. Our research seeks to understand how salt ions and other contaminants in water interact with polymer membranes. These interactions are critical for understanding how to manipulate polymer structure to optimize membrane selectivity for water purification applications.

Clean and Renewable Energy to Light our Future

Energy demand around the globe is projected to increase by more than 50% over the next 35 years, and sustainable, low-carbon footprint energy resources are needed to meet this increasing energy demand. While electricity generation from renewable sources is expected to grow over the next 25 years, the viability of this form of energy generation is challenged by the uneven nature of electricity production from many renewable sources, such as wind or solar power, so energy storage solutions are needed to capture this energy and provide it to the grid as needed. Large-scale flow and concentration batteries are being developed to meet these energy storage needs, and such batteries rely on selective membranes to regulate ion transport. Additionally, energy generation technologies, such as reverse electrodialysis and capacitive mixing, that harness energy from salt concentration differences are being developed, and these technologies seek to produce electricity by taking advantage of the chemical energy contained in solutions of different concentration. These technologies, like flow batteries, rely on polymer membranes to regulate ion transport. Membranes for energy technologies must be designed to function efficiently in ionic environments that are often very different from those encountered in natural water sources. Little is known about how different ions and complex ion mixtures influence polymer membrane transport properties, and our research seeks to understand fundamental relationships between ions and polymers that contribute to selectivity in energy applications. Improved membrane selectivity, achieved by optimizing polymer chemistry and structure, for energy applications will enable development of improved renewable energy storage and generation technologies.

RECENT RESEARCH DEVELOPMENTS

- Published a study on water and salt transport properties of zwitterionic polymer films
- Uncovered ion specific effects in charged polymers for energy applications
- 2015 NAMS Young Membrane Scientist Award
- Recent review article: G.M. Geise, et al., *Prog. Polym. Sci.*, 39 (2014) 1-42.

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