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Structure/property relationships in polymer membranes for water purification and energy applications

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Providing sustainable supplies of purified water and energy is a critical global challenge for the future, and polymer membranes will play a key role in addressing these clear and pressing global needs for water and energy. Polymer membrane-based processes dominate the desalination market, and polymer membranes are crucial components in several rapidly developing power generation and storage applications that rely on membranes to control rates of water and/or ion transport. Much remains unknown about the influence of polymer structure on intrinsic water and ion transport properties, and these relationships must be developed to design next generation polymer membrane materials. For desalination applications, polymers with simultaneously high water permeability and low salt permeability are desirable in order to prepare selective membranes that can efficiently desalinate water, and a tradeoff relationship between water/salt selectivity and water permeability suggests that attempts to prepare such materials should rely on approaches that do more than simply vary polymer free volume. One strategy is to functionalize hydrocarbon polymers with fixed charge groups that can ionize upon exposure to water, and the presence of charged groups in the polymer influences transport properties. Additionally, in many emerging energy applications, charged polymers are exposed to ions that are very different from sodium and chloride. Specific ion effects have been observed in charged polymers, and these effects must be understood to prepare charged polymers that will enable emerging energy technologies. This presentation discusses research aimed at further understanding fundamental structure/property relationships that govern water and ion transport in charged polymer films considered for desalination and electric potential field-driven applications that can help address global needs for clean water and energy.