Synthesis and Characterization of Poly(arylene ether sulfone)s for Reverse Osmosis Water Purification and Gas Separation Membranes

Benjamin James Sundell

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Macromolecular Science and Engineering

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Keywords: Reverse osmosis water purification, gas separation, polymer synthesis, poly(arylene ether sulfone), crosslinking, membrane fabrication

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Figure 1.2 Overall principle of osmosis compared to reverse osmosis

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Figure 1.4 and 1.5 Flux and rejection data for FilmTec Corp., FT30 membrane

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Figure 1.7 RO membrane fouling

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Figure 1.8 Flow of water and pressures present in FO, PRO and RO

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Figure 1.9 Graphic of PRO process

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Polymers **2013**, *5*(1), 303-327; doi:10.3390/polym5010303

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Review

Pressure Retarded Osmosis and Forward Osmosis Membranes: Materials and Methods

Inger Lise Alsvik and **May-Britt Hägg** *

Authors' affiliation

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Abstract: In the past four decades, membrane development has occurred based on the demand in pressure driven processes. However, in the last decade, the interest in osmotically driven processes, such as forward osmosis (FO) and pressure retarded osmosis (PRO), has increased. The preparation of customized membranes is essential for the development of these technologies. Recently, several very promising membrane preparation methods for FO/PRO applications have emerged. Preparation of thin film composite (TFC) membranes with a customized polysulfone (PSf) support, electorspun support, TFC membranes on hydrophilic support and hollow fiber membranes have been reported for FO/PRO applications. These novel methods allow the use of other materials than the traditional asymmetric cellulose acetate (CA) membranes and TFC polyamide/polysulfone membranes. This review provides an outline of the membrane requirements for FO/PRO and the new methods and materials in membrane preparation.

Keywords: pressure retarded osmosis; forward osmosis; membrane preparation; materials; methods

Figure 1.10 Concentration polarization in PRO membranes

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Figure 1.11 Membrane modules for separation applications

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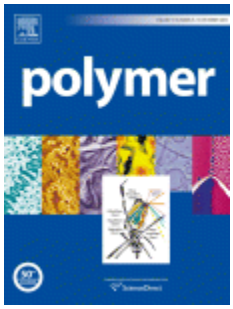

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Figure 1.12 Timeline of industrial development for gas separation membranes

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Figure 1.13 Upper-bound plot for Oxygen/Nitrogen Separations

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Figure 1.20 Degradation of SW30HR polyamide membrane compared to sulfonated polysulfone

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Figure 1.34 Ionically crosslinked polysulfone using acid-base chemistry

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Table 1.1 Effect of crosslinking on membrane selectivity[14]

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Figure 2.2 Li Calibration Curve for Pure SDCDPS

"From Polymer 2008, 49, 3014. Paul, M.; Park, H. B.; Freeman, B. D.; Roy, A.; McGrath, J. E.; Riffle, J. S. Li, Y.; VanHouten, R. A.; Brink, A. E.; McGrath, J. E. Purity characterization of 3,3′-disulfonated-4,4′-dichlorodiphenyl sulfone (SDCDPS) monomer by UV–vis spectroscopy. Used with permission of Elsevier, 2008."

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Figure 7.1 Salt passage of BPS copolymers and aromatic polyamides in the presence of calcium

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