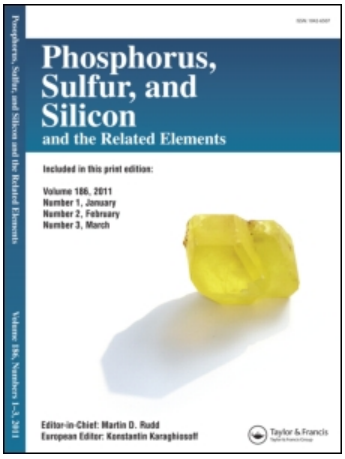

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Separations using Polyphsphazene Membranes

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Reported in this paper are the separation characteristics and transport mechanisms of membranes formed from poly[bis(phenoxy)phosphazene] based polymers. Separations of industrial interest include water purification, gas separations, liquid state organic-water and organic-organic separations. Many of these environments are chemically aggressive which often leads to the failure of many standard organic-based membrane materials and the polyphosphazenes have been observed to effectively operate in such environments. In this paper, we will develop an argument that shows the value of custom tailoring these membrane materials to fit the specific application of water purification.

Keywords: Membrane separations; polyphosphazenes; water purification; industrial separations; membrane dehydration; ion separations

INTRODUCTION

The Idaho National Engineering and Environmental Laboratory's Inorganic Membrane Technology Research Program (INEEL-IMTRP) is an ongoing Department of Energy (DOE) effort to develop energy efficient membrane processes in collaboration with industry.[1,2] The INEEL-IMTRP has focussed upon understanding the behavior of the phosphazenes as membranes for the past several years.[3,4,5,6,7,8,9,10,11] Gas, vapor, fluid transport, and laboratory scale membrane module separation behaviors have been reported in previous publications. [3-13] To evaluate polymer interactions, polymer swelling studies coupled with liquids and solids NMR spectroscopic characterizations were

performed.[12] The polymers used for these studies were made in-house, according to previously referenced methods[16] and functionalized with a variety of ligands. Polymer characterization included NMR spectra (Bruker WP300P), differential scanning calorimetry (TA Instruments Model 2910 DSC), thermomechanical analysis (TA Instruments Model 2910 TMA), molecular weight determination by multiangle light scattering (Wyatt Technologies), and solvent swelling studies. General Electric Corp supplied a membrane polydimethylsiloxane membrane. Flat sheet and tube-in shell membranes were prepared as previously reported. [3-6] The procedure for testing the water passing membranes follows our previously described pervaporation systems.[7] Fluxes were collected in liquid nitrogen traps and masses of liquids per predesignated time period recorded. Calculation of fluxes and modeling of the active system was performed using fundamental solution-diffusion equations found in the literature.[13]

RESULTS

Tables 1- 5 summarize the water passing performance of the membranes for a variety of applications including acetic acid dehydration, propylene glycol dehydration, diethylamine dehydration, dye removal from water, and metal ion filtration from dilute streams.

Table 1. Dehydration of acetic acid using trifluoroehtoxy/p-phenoxyamino phosphazene.

Temperature (°C)	Trans Membrane Pressure (Atm.)	Feed Flow (ml/min)	Water Flux (LM^{-2} -hr)	Acetic Acid Rejection (%)
40	1	75	0.04	88
40	1	75	0.03	80

Table 2. Dehydration of acetic acid using diethyleneglycol, p-methoxyphenoxy phosphazene.

Temperature (°C)	Trans Membrane Pressure (Atm.)	Feed Flow (ml/min)	Water Flux (LM^{-2} - hr)	Acetic Acid Rejection (%)
22	1	75	0.04	12
40	1	75	0.05	19

Table 3. Dehydration of acetic acid using p-methoxyphenoxy phosphazene

Temperature (°C)	Trans Membrane Pressure (Atm.)	Feed Flow (ml/min)	Water Flux (LM^{-2} -hr)	Acetic Acid Rejection (%)
40	1	75	0.02	57
40	1	75	0	--

Table 4. Diethylamine-Water Separations using phosphazene polymers.

Polymer	Temperature (°C)	Water Flux (LM^{-2}-hr)	Diethylamine Rejection (%)	Comments
1	23	--	--	Failed immediately
2	38	0.12	83	6 hour lifetime
3	22	0.31	97	
4	22	0.12	99	

Table 5. Pervaporation of water from green food coloring.

Polymer	Temperature (°C)	Water Flux (LM^{-2}-hr)	Food Coloring Rejection (%)
DE-pME	38	0.36	99+
DE-pME	37	0.76	99+
DE-pME-CH	30	1.05	99+
DE-pME	30	0.71	99+
DE-pME	24	0.53	99+
DE-pME	38	Various	99+

SUMMARY

Several different separations tailoring polyphosphazene materials' properties to specific separations have been described in this paper. The unique ability to match a specific polymer to separation of water from various streams has been and shown to be quite useful. Specific examples of matching the polymers to a separation described in this paper include: acetic acid dehydration, both ethylene glycol and

propylene glycol dehydration, diethylamine dehydration, dye removal from water, and metal ion filtration from dilute streams.

References

[1] R.W. Baker, E.L. Cussler, W. Eykamp, W.J. Koros, R.L. Riley, H. Strathmann, *Membrane Separations Systems – A Research and Development Needs Assessment*,U.S. DOE Contract No. DE-AC01–88ER30133, March, 1990.

[2] J.L. Humphrey, A.F. Seibert, R.A. Koort, *Separation Technologies – Advances and Priorities*, U.S. DOE Contract No. AC07–90D12920, February, 1991.

[3] R.R. Mcaffrey, D.G. Cummings, *Sep. Sci. and Tech.*, **23**, (12,13), 1627 (1988).

[4] C.A. Allen, D.G. Cummings, A.E. Grey, R.E. McAtee, R.R. McCaffrey, *J. Memb. Sci.*, **33**, 181 (1987).

[5] R.R. Mcaffrey, R.E. McAtee, A.E. Grey, C.A. Allen, D.G. Cummings, A.D. Applehans, *J. Memb. Sci.*, **28**, 47, (1986).

[6] D.A. Femec, R.R. McCaffrey, *J. Appl. Poly. Sci.*, **52**, 501 (1994).

[7] E.S. Peterson, M.L. Stone, W.F. Bauer, C.J. Orme, *Rec. Prog. En Geni des Proc.*, Membrane Processes, **6**, (22), 381 (1992).

[8] E.S. Peterson, M.L. Stone, R.R. McCaffrey, D.G. Cummings, *Sep. Sci and Tech.*, **28**, (1–3) (1993).

[9] E.S. Peterson, M.L. Stone, *J. Memb. Sci.*, **86**, 57 (1994).

[10] E.S. Peterson, M.L. Stone, C.J. Orme, D.A. Reavill III, *Sep. Sci. and Tech.*, **30**, (7–9), 1573 (1995).

[11] E.S. Peterson, M.L. Stone, C.J. Orme, U.S. Patent # 5,385,672, January, 1995.

[12] F.F. Stewart. E.S. Peterson, S.C. Bussse, C.J. Orme, *Chem. of Materials*, **9**, 155 (1997).

[13] J.G. Wijmans, R.W. Baker, *J. Memb. Sci.*, **107**, 1, (1995).