

Vita

Richard D. Noble

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Title: Alfred T. and Betty E. Look Professor of Chemical Engineering
Co-Director, NSF I/U CRC Membrane Applied Science and Technology Center
University of Colorado, Boulder, Colorado 80309-0424

Registered Professional Engineer (Colorado License No. 18922)

Date and Place of Birth: October 14, 1946, Newark, New Jersey

Education:

B.E. (Honors) Chemical Engineering, Stevens Institute of Technology, 1968

M.E. (Chemical) Chemical Engineering, Stevens Institute of Technology, 1969

Ph.D. Chemical Engineering, University of California, Davis, 1976

Work Experience

University of Colorado Chemical Engineering Department Boulder, CO 80309-0424	9/90 - present	Professor Co-Director, NSF I/U CRC Membrane Applied Science and Technology Center (MAST)
	9/87 - 8/90	Research Professor
	4/83 - 9/87	Associate Professor Adjunct of Chemical Engineering
	8/81 - 4/83	Assistant Professor Adjunct of Chemical Engineering
National Bureau of Standards Center for Chemical Engineering Boulder, CO 80303	5/81 - 9/87	Chemical Engineer
University of Wyoming Mineral Engineering Department Laramie, WY 82071	4/76 - 5/81	Assistant Professor of Chemical Engineering
National Starch and Chemical Co. Plainfield, NJ	6/68 - 1/71	Design Engineer

Honors and Awards

Outstanding Faculty Member, University of Wyoming, Chemical Engineering Department, 1979-1980, 1980-1981.

Halliburton Education Foundation Award of Excellence: Outstanding Faculty Member, Engineering College, University of Wyoming, 1979-1980 (\$500).

American Society for Engineering Education (ASEE) Zone IV Campus Activity Coordinator Award, 1979-1980.

ASEE Dow Outstanding Young Faculty Award, Rocky Mountain Section, 1981.

National Bureau of Standards Outstanding Performance Award, 1983 (\$700).

National Bureau of Standards Sustained Superior Performance Award, 1984 (\$1500).

ASEE AT&T Foundation Award, Rocky Mountain Section, 1985 (\$1500).

National Bureau of Standards Sustained Superior Performance Award, 1985 (\$1200).

National Bureau of Standards Sustained Superior Performance Award, 1987 (\$500).

ASEE Centennial Certificate of Recognition (1993).

Professor Recognition Award, Mortar Board Senior Honor Society (1993).

Outstanding Undergraduate Professor Award, Chemical Engineering Dept. (1993).

ACS Colorado Section Award, 1994 (\$500).

University of Colorado Bank One Colorado Corporation 1994-95 Faculty Community Service Award (\$2500)

College of Engineering Outstanding Research Award, 1995 (\$1000)

Outstanding Undergraduate Professor Award, Chemical Engineering Dept. (1995)

University of Colorado Faculty Council Award for Excellence, 1995 (\$3000)

Japan Industrial Technology Association Foreign Researcher Fellowship, 1996

Max S. Peters Faculty Service Award, College of Engineering, 1998 (\$1000)

Boulder Faculty Assembly Excellence in Service Award, 1999 (\$3000)

Outstanding Undergraduate Professor Award, Chemical Engineering Dept. (1999)

Boulder Faculty Assembly Excellence in Research Award, 2001 (\$3000)

Elected Fellow of AIChE, 2001

Fulbright Senior Specialist Grant, 2003

Outstanding Graduate Teaching Award, Chemical Engineering Dept. (2003)

UC Davis Distinguished Engineering Alumni Award (2003)

CU Residence Life Teaching Award (2004)

AIChE Institute Service to Society Award (2005)

Alfred T. and Betty E. Look Professor of Chemical Engineering (2005-present)

Outstanding Graduate Teaching Award, Chemical Engineering Dept. (2006)

ACS Industrial & Engineering Chemistry Division Fellow (2007)

Outstanding Graduate Teaching Award, Chemical Engineering Dept. (2007)

Outstanding Graduate Teaching Award, Chemical Engineering Dept. (2008)

CU Boulder Inventor of the Year (2008)

Barrer Lecture, Penn State University, (2008)

Fellow, Renewable and Sustainable Energy Institute (2009-2012)

Robert L. Stearns Award, CU Alumni Association, (2010)

Chair d'Excellence Pierre de Fermat, Paul Sabatier University, Toulouse, France (2010)

AIChE Institute Industrial Gas Technology Award (2010)

Professional Service

ASEE Educational Research and Methods Division, Director-at-Large, 1980-1982
AIChE Group 4 (Education and Consulting), Committee Member, 1980-1981
ASEE Rocky Mountain Section, Vice-Chairman - East, 1981
ASEE Educational Research and Methods Division, National Effective Teaching Institute Director, 1982
ASEE Educational Research and Methods Division, Distinguished Lecturer Series Director, 1982
ASEE Educational Research and Methods Division, Director, 1982-84
AIChE Technical Program, Vice-Chairman, AIChE Meeting, Denver, Colorado, August, 1983
ASEE Rocky Mountain Section, Awards Chairman, 1983
AIChE Research Committee, Member, 1982-1984
ASEE Rocky Mountain Section, Program Chairman, 1984 Meeting
ASEE Chemical Engineering Division, Program Chairman, 1984 Meeting
North American Membrane Society, Organizing Committee, 1984
ASEE Educational Research and Methods Division, Nominating Committee, 1984-1985
ACS Separation Science and Technology sub-division, Program Chairman, 1987 - 1989, Chairman-Elect, 1989, Chairman, 1990
Gordon Conference on Sep. and Purification, Vice Chairman, 1986, Chairman, 1987
AIChE Separations Division, Organizing Committee, 1989 - 1990 Second Vice Chair, 1991, Program Chair, 1992, Chair, 1993.
Industrial and Engineering Chemistry Research, Editorial Board, 1991-1993.
Editor, Special Issue on Membrane Catalysis, Journal of Membrane Science, 1993.
1994 North American Membrane Society (NAMS) Meeting, Technical Program Chair
North American Membrane Society (NAMS) Board of Directors, 1995-1997
Separation Science and Technology, Editorial Board, 1997-present
Editor, Separation and Purification Methods, 1998-2002
Gordon Conference on Membranes:Materials and Processes, Vice Chairman, 1997, Chairman, 2000
Advisory Board, Membrane Products Corporation, 1998-
Journal of Membrane Science, Editorial Board, 1999-
Separation and Purification Technology, Editorial Board, 2000-
Third International Zeolite Membrane Meeting, Chair, 2004
International Congress on Inorganic Membranes, Co-Chair, 2004
Separation and Purification Reviews, Editorial Board, 2004-
NAMS/ICIM technical program chair, 2010

Books and Monographs

1. "*Residence Time Distribution Theory in Chemical Engineering*," A. Petho and R.D. Noble, editors, Verlag-Chemie Publishing Co. (1982), 286 pages.
2. "*Problem Solving*," J.T. Sears, D.R. Woods, and R.D. Noble, editors, **AIChE Symposium Series 228**, 79 (1983), 63 pages.
3. "*Liquid Membranes: Theory and Applications*," R.D. Noble and J.D. Way editors, **ACS Symposium Series 347** (1987).

4. Noble, R.D., Way, J.D., and Bunge, A.L., "*Liquid Membranes*," Chapter 2 in **Ion Exchange and Solvent Extraction 10**, J.A. Morinsky and Y. Marcus, editors, Marcel Dekker Publishing Company (1987), pp. 63-103.
5. Noble, R.D., Pellegrino, J.J., and Koval, C.A., "*Overview of Facilitated Transport Membrane Systems*," **Chemical Engineering Progress**, 58-70, March, 1989.
6. Pellegrino, J.J. and Noble, R.D., "*Enhanced Transport and Liquid Membrane in Bio-Separations*," **Trends in Biotechnology**, 8: 8, 216-224 (1990).
7. Way, J.D. and Noble, R.D., "*Facilitated Transport*," Chap. 44 in **Membrane Handbook**, K.K. Sirkar and W.S. Ho, editors, Van Nostrand Publishing Co., (1992).
8. "*Membrane Separations Technology: Principles and Applications*," R.D. Noble and S.A. Stern, editors, Membrane Science and Technology Series, 2, Elsevier Pub. Co., (1995), 718 pages.
9. Falconer, J.L., Noble, R.D. and Sperry, D., "*Catalytic Membrane Reactors*," Chap. 14 in **Membrane Separations Technology: Principles and Applications**, R.D. Noble and S.A. Stern, editors, Membrane Science and Technology, 2, Elsevier Pub. Co., (1995).
10. Noble, R.D. and Terry, P.A., "*Principles of Chemical Separations with Environmental Applications*", Cambridge University Press (2004).
11. "*Membranes-Preparation, Properties and Applications*", V.N. Burganos, R.D. Noble, M. Asaeda, A. Ayril, and J.D. LeRoux, editors, Materials Research Society Proceedings, Vol. 752, (2003).
12. Noble, R.D., "*Overview of "Green" Separation Processes*", Chap. 3.1 In **Green Separation Processes**, C. A. M. Afonso and J. G. Crespo, editors, J. Wiley-VCH, (2005).
13. Noble, R.D. and Koval, C.A., "*Review of Facilitated Transport Membranes*", Chap. 17, **Materials Science of Membranes for Gas and Vapor Separation**, Y. Yampolskii, I. Pinnau and B.D. Freeman, editors, J. Wiley & Sons, Ltd., 2006.

Patents

1. Noble, R.D., Koval, C.A., Nixon, L. and Slaff, G.F., "*Stationary Magnetically Stabilized Fluidized Bed for Protein Separation and Purification*," U.S. Patent No. 5,084,169, Jan. 28, 1992.
2. Noble, R.D., Koval, C.A., Nixon, L. and Slaff, G.F., "*Method for Preparing Magnetizable Porous Particles*," U.S. Patent No. 5,110,624, May 5, 1992.
3. Noble, R.D., Koval, C.A., Nixon, L. and Slaff, G.F., "*Stationary Magnetically Stabilized Fluidized Bed for Protein Separation and Purification*," U.S. Patent No. 5,130,027, July 14, 1992.
4. Foster, N.S., Koval, C.A., and Noble, R.D., "*Reversible Photodeposition and Dissolution of Metal Ions*" U.S. Patent No. 5,332,508, July 26, 1994.
- 5.-7. Rakowski-DuBois, M., Noble, R.D. and Koval, C.A., "*Methods of Production of Novel Molybdenum-Sulfide Dimers and Reactions of the Same*" U.S. Patent No. 5,391,791, February 21, 1995; U.S. Patent No. 5,414,194, May 9, 1995; U.S. Patent No. 5,430,225, July 4, 1995.
8. Pellegrino, J.J., Rabago, R., Noble, R.D. and Koval, C.A., "*Enhancing Performance of Perfluorinated Ionomer Membranes via Dopant Incorporation*" U.S. Patent No. 5,417,832, May 23, 1995.

9. Thoen, P., Koval, C.A. and Noble, R.D., “*Unexpectedly Large Selectivities for Olefin Separations Utilizing Silver Ion in Ion-Exchange Membranes*” U.S. Patent No. 5,498,823, March 12, 1996.
10. Jia, M-D, Noble, R.D. and Falconer, J.L., “*Ceramic-Zeolite Membranes and Use for Separation of Vapor/Gas Mixtures*” U.S. Patent No. 5,464,798, November 7, 1995.
11. Sczechowski, J.G., Koval, C.A. and Noble, R.D., “*Use of Controlled Periodic Illumination for an Improved Method of Photocatalysis and an Improved Reactor Design*” U.S. Patent No. 5,439,652, August 8, 1995.
- 12.& 13. Noble, R.D. and Clark, N.A., “*Convective Electrohydrodynamic Fluid Membranes*” U.S. Patent No. 5,433,857, July, 18,1995, U.S. Patent No. 5,441,639, August 15, 1995.
- 14.& 15. Falconer, J.L., George, S.M., Ott, A.W., Klaus, J.W., Noble, R.D. and Funke, H.H., “*Modification of Zeolite or Molecular Sieve Membranes Using Atomic Layer Controlled Chemical Vapor Deposition*”, U.S. Patent No. 6,043,177, March 28, 2000, “*Modified Zeolite Membrane*”, U.S. Patent No. 6,051,517, April 18,2000.
- 16.&17. Tuan, V.A., Noble, R.D. and Falconer, J.L., “*Isomorphously Substituted Molecular Sieve Membranes*”, U.S. Patent No. 6,767,384, July 27, 2004, U.S. Patent No. 7,074,734, July 11, 2006.
18. Li, S.; Arvidson, S.; Falconer, J.L. and Noble, R.D., “*Highly Selective Supported SAPO Membranes*”, U.S. patent 7,316,727, January 8, 2008.
19. Gin, D.; Zhou, M. and Noble, R.D., “*Lyotropic Liquid Crystal Nanofiltration Membranes*”, U.S. Patent No. 7,604,129, October 20, 2009.
20. Koval, C.A.; Evans, C.E.; Noble, R.D.; and Norman, M.A., “*Electrochemical High Pressure Pump*”, U.S. Patent 7,718,047, May 18, 2010.
21. Gin, D.; Bara, J.;Noble, R.D.; and Zeng, X., “*Surfactants and Polymerizable Surfactants Based on Room-Temperature Ionic Liquids that Form Lyotropic Liquid Crystal Phases with Water and Room-Temperature Ionic Liquids*”, U.S. Patent Application.
22. Falconer, J.L.; Carreon, M.; Li, S. and Noble, R.D., “*Synthesis of Zeolites and Zeolite Membrane Using Multiple Structure Directing Agents*”, U.S. Patent Application.
23. Falconer, J.L.; Li, S.; Noble, R.D. and Yu, M.; “*Reversible Hydrogen Storage using Zeolite Layers*”, U.S. Patent Application.
24. Falconer, J.L.; Li, S.; Noble, R.D. and Yu, M.; “*A Controllable Nanometer Sized Valve*”, U.S. Patent Application.
25. Wyse, C.L.; Torres, R.; Millward, A.R.; Noble, R.D.; Bara, J. and Gin, D. “*Fluid Storage and Purification Method and System*”, U.S. Patent Application.
26. Camper, D.; Bara, J.; Gin, D.L. and Noble, R.D. “*Compositions and Methods for Removing Acid Gases*”, U.S. Patent Application.

Refereed Publications - Technical

1. Jackman, A.P., Noble, R.D., and Bonovrie, H.J., "*Inexpensive Recording Thermometer*," **Review of Scientific Instruments**, **48**: 7, 865-869 (July 1977).
2. Jackman, A.P. and Noble, R.D., "*Field Recalibration of Radiometers Using the Shading Technique*," **U.S. Geological Survey Journal of Research** **4**: 6, 757-764 (November-December, 1976).
3. Noble, R.D. and Jackman, A.P., "*Meteorological, Water Temperature, and Flow Rate Data for the Mattole River Basin*," **U.S. Geological Survey Water Resources Investigations**, **78-81** (1978).
4. Noble, R.D., "*Analytical Prediction of Natural Temperature in Rivers*," **ASCE Journal of Environmental Engineering Division EE5**, 1014-1018 (October, 1979).
5. Noble, R.D. and Jackman, A.P., "*Predicting the Natural Water Temperature Profile Throughout a River Basin*," **Journal of Environmental Systems**, **9**: 4, 361-381 (1979-1980).
6. Noble, R.D., "*Comparison of Two Surface Heat Exchange Models*," **ASCE Journal of Hydraulics Division**, **107**: HY3, 361-366 (March, 1981).
7. Noble, R.D., Tucker, W.F., and Harris, H.G., "*Isothermal Oil Shale Pyrolysis: 2. Kinetics of Product Formation and Composition at Various Pressures*," **Fuel**, **60**, 573-576 (July, 1981).
8. Noble, R.D. and Carroll, T.A., "*Analytical Prediction of Vertical Temperature Distribution in Large Water Bodies*," **Journal of Environmental Systems**, **11**:2, 131-138 (1981).
9. Noble, R.D., Tucker, W.F., and Harris, H.G., "*Isothermal Oil Shale Pyrolysis: 1. Oil Generation and Composition at Various Pressures*," **Fuel**, **61**, 482-484 (May, 1982).
10. Carroll, T.A. and Noble, R.D., "*Daily Absorbed Solar Radiation at Air-Water Interface*," **Journal of Environmental Systems**, **11**: 4, 289-294 (1982).
11. Noble, R.D., "*Mathematical Modeling in the Context of Problem Solving*," **Mathematical Modeling**, **3**, 215-219 (1982).
12. Wang, C. and Noble, R.D., "*Composition and Kinetics of Oil Generation From Nonisothermal Oil Shale Retorting*," **Fuel**, **62**, 529-533 (May, 1983).
13. Richardson, S.A. and Noble, R.D., "*Anxiety: Another Aspect of Problem Solving*," **AIChE Symposium Series on Problem Solving**, **79**: 228, 28-32 (1983).
14. Carroll, T.A., Noble, R.D., and Buschman, R.G., "*Analytical Prediction of the Hourly Temperature Variation in Rivers*," **Journal of Environmental Systems**, **12**: 3, 279-288 (1983).
15. Way, J.D., Noble, R.D., Flynn, T.A., and Sloan, E.D., "*Liquid Membrane Transport: A Survey*," **Journal of Membrane Science**, **12**, 239-259 (1982).
16. Folkner, C.A. and Noble, R.D., "*Transient Response of Facilitated Transport Membranes*," **Journal of Membrane Science**, **12**, 289-301 (1983).
17. Noble, R.D., "*Shape Factors in Facilitated Transport*," **Industrial and Engineering Chemistry Fundamentals**, **22**: 1, 139-144 (1983).
18. Kemena, L.L., Noble, R.D., and Kemp, N.J., "*Optimal Regimes in Facilitated Transport*," **Journal of Membrane Science**, **15**, 259-274 (1983).

19. Wankat, P.C. and Noble, R.D., "*Calculations for Separations with Three Phases: 2. Continuous Contact Systems*," **Industrial and Engineering Chemistry Fundamentals**, **23**, 137-143 (1984).
20. Buschman, R.G. and Noble, R.D., "*Laplace Transformation Methods for Some Heat Transfer Problems*," **Indian Journal of Pure and Applied Mathematics**, **14**: 5, 575-580 (May, 1983).
21. Noble, R.D., Bushman, R.G., and Kemp, N.J., "*Vertical Temperature Distributions in Lakes*," **Journal of Environmental Systems**, **14**: 1, 63-75 (1984).
22. Kemp, N.J. and Noble, R.D., "*Heat Transfer Effect in Facilitated Transport Liquid Membranes*," **Separations Science and Technology**, **18**, 1147-1165 (1984).
23. Bunge, A.L. and Noble, R.D., "*A Diffusional Model for Reversible Consumption in Emulsion Liquid Membranes*," **Journal of Membrane Science**, **21**, 55-71 (1984).
24. Noble, R.D., "*Two Dimensional Permeate Transport with Facilitated Transport Membranes*," **Separations Science and Technology**, **19**: 8&9, 469-478 (1984).
25. Way, J.D., Noble, R.D., and Bateman, R.B., "*Selection of Supports for Immobilized Liquid Membranes*," published in "**Material Science of Synthetic Membranes**," **ACS Symposium Series 269**, D.L. Lloyd, editor, 330-333 (1984).
26. Niiya, K.Y. and Noble, R.D., "*Competitive Facilitated Transport Through Liquid Membranes*," **Journal of Membrane Science**, **23**: 2, 183-198 (1985).
27. Noble, R.D., "*Kinetic Efficiency Factors for Facilitated Transport Membranes*," **Separations Science and Technology**, **20**: 7&8, 577-585 (1985).
28. Koval, C.A., Noble, R.D., Way, J.D., Louie, B., Reyes, Z., Horn, G., and Reed, D., "*The Selective Transport of Gaseous CO Through Liquid Membranes Using an Iron (II) Macrocyclic Complex*," **Journal of Inorganic Chemistry**, **24**, 1147-1152 (1985).
29. Leiber, J.P., Noble, R.D., Way, J.D., and Bateman, B.R., "*Mathematical Modeling of Facilitated Liquid Membrane Transport Systems Containing Ionically Charged Species*," **Separations Science and Technology**, **20**: 4, 231-256 (1985).
30. Hanna, G.J. and Noble, R.D., "*Measurement of Liquid-Liquid Interfacial Kinetics*," **Chemical Reviews**, **85**, 583-598 (1985).
31. Noble, R.D., Way, J.D., and Powers, L.A., "*Effect of External Mass Transfer Resistance on Facilitated Transport*," **Industrial and Engineering Chemistry Fundamentals**, **25**: 3, 450-452 (1986).
32. Noble, R.D., Way, J.D., and Powers, L.A., "*Boundary Layer Effects in Facilitated Transported Liquid Membranes*," **AIChE Symposium Series on Industrial Membrane Processes**, **82**: 248, 94-97 (1986).
33. Noble, R.D., "*An Overview of Membrane Separations*," **Separations Science and Technology**, **22**: 2&3, 731-743 (1987).
34. Baird, R.S., Bunge, A.L., and Noble, R.D., "*Batch Extraction of Amines Using Emulsion Liquid Membranes: Importance of Reaction Reversibility*," **AIChE Journal**, **33**: 1, 43-53 (1987).
35. Reed, D.L., Bunge, A.L., and Noble, R.D., "*Influence of Reversible Consumption on Continuous Flow Extraction by Emulsion Liquid Membranes*," in "**Liquid Membranes: Theory and Applications**," **ACS Symposium Series 347**, R.D. Noble and J.D. Way, editors, 62-85 (1987).

36. Way, J.D., Noble, R.D., Reed, D.L., Ginley, G.M., and Jarr, L.A., "Facilitated Transport of CO₂ in Ion Exchange Membranes," **AIChE Journal**, **33**: 3, 480-487 (1987).
37. Hanna, G.J., Noble, R.D., and Michel, F.C., Jr., "Interfacial Resistance for Carboxylic Acid Transfer from Decane to Water," **Journal of Physical Chemistry**, **91**: 2, 362-365 (1987).
38. Noble, R.D. and Danesi, P.R., "Steady-State Coupled Transport of HNO₃ Through a Hollow Fiber Supported Liquid Membrane," **Liquid Membranes: Theory and Applications**, ACS Symposium Series **347**, R.D. Noble and J.D. Way, editors, 56-61 (1987).
39. Noble, R.D. and Way, J.D., "Liquid Membrane Technology: An Overview," **Liquid Membranes: Theory and Applications**, ACS Symposium Series **347**, R.D. Noble and J.D. Way, editors, 1-27 (1987).
40. Way, J.D. and Noble, R.D., "Hydrogen Sulfide Facilitated Transport in Perfluorosulfonic Acid Membranes," **Liquid Membranes: Theory and Applications**, ACS Symposium Series **347**, R.D. Noble and J.D. Way, editors, 123-137 (1987).
41. Noble, R.D. and Way, J.D., "Applications of Liquid Membrane Technology," **Liquid Membranes: Theory and Applications**, ACS Symposium Series **347**, R.D. Noble and J.D. Way, editors, 110-122 (1987).
42. Kirkkopru, A., Noble, R.D., and Bunge, A.L., "Amine Phase Partitioning Using Emulsion Liquid Membranes," **Chemical Engineering Communications**, **64**, 207-215 (1988).
43. Noble, R.D., "Model for Time Lag in Signal Concentration for Product Removal in a One Dimensional Column," **Separations Science and Technology**, **23**: 4&5, 513-518 (1988).
44. Noble, R.D., "Relationship of System Properties to Performance in Facilitated Transport Systems," **Gas Separation and Purification**, **2**:1, 16-19 (1988).
45. Noble, R.D., Pellegrino, J.J., Grosogeat, E., Sperry, D., and Way, J.D., "CO₂ Separation Using Facilitated Transport Ion Exchange Membranes," **Separations Science and Technology**, **23**: 12 & 13, 1595-1609 (1988).
46. Koval, C.A., Drew, S.M., Spontarelli, T., and Noble, R.D., "Concentration and Removal of Nitrogen and Sulfur Compounds from Hydrocarbon Phases Using Electrochemically Reversed Chemical Complexation," **Separations Science and Technology**, **23**: 12 & 13, 1389-1399 (1988).
47. Pellegrino, J.J., Nassimbene, R., and Noble, R.D., "Facilitated Transport of CO₂ Through Highly Swollen Ion-Exchange Membranes: The Effect of Hot Glycerine Pretreatment," **Gas Separation and Purification**, **2**: 126-130 (1988).
48. Kirkkopru, A. and Noble, R.D., "Optimal Regimes of Facilitated Transport for Multiple Site Carriers," **Journal of Membrane Science**, **42**: 13-25 (1989).
49. Jin, M.F., Michel, F.C., Jr., and Noble, R.D., "Kinetics of Copper Extraction Using (anti) -2- Hydroxy -5- Nonylbenzophenone Oxime," **I&EC Research**, **28**: 193-198 (1989).
50. Tallarico, J.P., Noble, R.D., and Hanna, G.J., "Study of the Kinetics of Copper Extraction with -2- Hydroxy -5- Nonylbenzophenone Oxime Using a Rotating Diffusion Cell," **Separations Science and Technology**, **24**: 3&4, 199-217 (1989).

51. Koval, C.A., Spontarelli, T., and Noble, R.D., "*Styrene/Ethylbenzene Separation Using Facilitated Transport Through Perfluorsulfonate Ionomer Membranes*", **I & E C Research**, **28**:1020-1024 (1989).
52. Chaara, M. and Noble, R.D., "*Effect of Convective Flow Across a Film on Facilitated Transport*", **Separations Science and Technology**, **24**:11, 893-903 (1989).
53. Way, J.D. and Noble, R.D., "*Competitive Facilitated Transport of Acid Gases in Perfluorosulfonic Acid Membranes*," **Journal of Membrane Science**, **46**, 309-324 (1989).
54. Noble, R.D., "*Optimal Equilibrium Constants for Interfacial Reactions Used in Liquid Membrane Transport*," **Separations Science and Technology**, **24**, 1329-1336 (1989).
55. Noble, R.D., Giubileo, G., Violante, V. and Fabiani, C., "*Analysis of Enzyme Catalysis Under Batch Condition*," **Chemical Engineering Journal**, **44**, B47-B50 (1990).
56. Noble, R.D., Violante, V., Giubileo, G. and Fabiani, C., "*Analysis of an Implantable Bio-Artificial Pancreas for Insulin Production*," **Chemical Engineering Journal**, **44**, B81-B86 (1990).
57. Noble, R.D., "*Analysis of Facilitated Transport with Fixed Site Carrier Membranes*," **Journal of Membrane Science**, **50**, 207-214 (1990).
58. Koval, C.A., Drew, S.M., Noble R.D., and Yu, J., "*The Electrochemistry of a Water-Soluble Iron Porphyrin and its Exploitation for Selective Removal and Concentration of Environmentally Hazardous Materials via Electrochemically Modulated Complexation*," **Journal of Inorganic Chemistry**, **29** (23) 4708-4714 (1990).
59. Noble, R.D., "*Analysis of Ion Transport with Fixed Site Carrier Membranes*," **Journal of Membrane Science**, **56**, (2) 229-231 (1991).
60. Vant Hull, B. and Noble, R.D., "*Moment Analysis of Transient Membrane Permeation with an Immobilizing Chemical Reaction*," **I&EC Research**, **29**, 728-733 (1991).
61. Jemaa, N., Noble, R.D., and Koval, C.A., "*Electrochemically Modulated Equilibrium Stage Processes*," **Chemical Engineering Science**, **46** (4), 1017-1026 (1991).
62. Sperry, D.P., Falconer, J.L., and Noble, R.D., "*Methanol-Hydrogen Separation by Capillary Condensation in Inorganic Membranes*," **Journal of Membrane Science**, **60** (2&3), 185-194 (1991).
63. Noble, R.D., "*Facilitated Transport Mechanism in Fixed Site Carrier Membranes*," **Journal of Membrane Science**, **60** (2&3), 297-306 (1991).
64. Noble, R.D., "*Facilitated Transport with Fixed Site Carrier Membranes*," **Journal of the Chemical Society, Faraday Transactions of Physical Chemistry and Chemical Physics No. 13**, 2089-2092 (1991).
65. Dindi, A., Noble, R.D., Yu, J. and Koval, C.A., "*Experimental and Modeling Studies of a Parasitic Binding Mechanism in Facilitated Membrane Transport*," **Journal of Membrane Science**, **66**, 55-68 (1992).
66. Dindi, A., Noble, R.D. and Koval, C.A., "*An Analytical Solution for Competitive Facilitated Membrane Transport*," **Journal of Membrane Science**, **65** (1&2), 39-45 (1992).

67. Jemaa, N., Noble, R.D. and Koval, C.A. "*Combined Mass and Energy Balance Analysis of an Electrochemically Modulated Equilibrium Stage Process*," **Chemical Engineering Science**, **47** (6), 1469-1479 (1992).
68. Elkamel, A. and Noble, R.D., "*A Statistical Mechanics Approach to the Separation of Methane and Nitrogen Using Capillary Condensation in a Microporous Membrane*," **Journal of Membrane Science**, **65** (1&2) 163-172 (1992).
69. Elkamel, A. and Noble, R.D., "*The Prediction of Capillary Condensation in Small Cylindrical Pores Using the Local Density Approximation and a Full Lennard-Jones 6-12 Potential*," **Journal of Physical Chemistry**, **95**, no. 24, 10076-10080 (1991).
70. Nixon, L., Koval, C.A., Xu, L., Noble, R.D. and Slaff, G.S., "*The Effects of Magnetic Stabilization on the Structure and Performance of Liquid-Fluidized Beds*," **Bioseparation**, **2**, 217-230 (1991).
71. Ozekin, K., Noble, R.D. and Koval, C.A., "*Theoretical Analysis of Extraction Using Chemically Mediated Electrochemically Modulated Complexation in Ion Exchange Beads*," **Separations Technology** **2**, 29-38 (1992).
72. Nixon, L., Koval, C.A., Noble, R.D. and Slaff, G.S., "*Preparation and Characterization of Novel Magnetite-Coated Ion-Exchange Particles*", **Chemistry of Materials**, **4** (1), 117-121 (1992).
73. Jemaa, N., Yu, J., Noble, R.D., Drew, S.M., Wedman, D.E. and Koval, C.A., "*Two Methods to Study Aggregation of Complexing Agents Used to Alter Solute Partitioning Between Phases*", **Separations Science and Technology**, **27** (7) 901-915 (1992).
74. Koval, C.A., Spontarelli, T., Thoen, P. and Noble, R.D., "*Swelling and Thickness Effects on the Separation of Styrene and Ethylbenzene Based on Facilitated Transport Through Ionomer Membranes*", **I & EC Research**, **31**, 1116-1122 (1992).
75. Jemaa, N. and Noble, R.D., "*Improved Analytical Prediction of Facilitation Factors in Facilitated Transport*", **Journal of Membrane Science**, **70**, 289-293 (1992).
76. Noble, R.D., "*Generalized Microscopic Mechanism of Facilitated Transport in Fixed Site Carrier Membranes*," **Journal of Membrane Science**, **75** (1&2), 121-129 (1992).
77. Wan, C., Noble, R.D. and Clark, N.A., "*Control of Gas Permeation via Electrohydrodynamic Convection in a Liquid Crystal Membrane*," **Journal of Membrane Science**, **74**, 223-231 (1992).
78. To, T.T., Noble, R.D. and Koval, C.A., "*Effects of Protonation on the Transport of Hydrophobic Nitrogen Heterocycles through Perfluorosulfonate Ionomer Membranes*," **Journal of Membrane Science**, **75** (3), 293-297 (1992).
79. Gokhale, Y.V., Noble, R.D. and Falconer, J.L., "*Analysis of a Membrane Enclosed Catalytic Reactor for Butane Dehydrogenation*," **Journal of Membrane Science**, **77** (2&3), 197-206 (1993).
80. Foster, N.S., Noble, R.D. and Koval, C.A., "*Reversible Deposition and Oxidative Dissolution of Copper Ions in Titanium Dioxide Aqueous Suspensions*" **Environmental Science and Technology**, **27** (2), 350-356 (1993).

81. Jemaa, N., Walls, H.J., Noble, R.D., Wedman, D.E. and Koval, C.A., "*Continuous Electrochemically Modulated Complexation Separation Process*", **AICHE Journal**, **39**(5), 867-875 (1993).
82. Funke, H.H.; Noble, R.D. and Koval, C.A., "*Separation of Gaseous Olefin Isomers Using Facilitated Transport Membranes*", **Journal of Membrane Science**, **82**, 229-236 (1993).
83. Noble, R.D.;Falconer, J.L.;Jia, M.D. and Perkins, T.W., "*Separation of Methanol-Hydrogen Mixtures Using Inorganic Membranes*", **Journal of Membrane Science**, **79**, 123-125 (1993).
84. Foster, N.S.;Brown, G.N.;Noble, R.D. and Koval, C.A., "*Use of TiO₂ Photocatalysis in the Treatment of Spent Electroless Copper Plating Baths*", **Photocatalytic Purification and Treatment of Water and Air**, D.F. Ollis and H. Al-Ekabi, editors, Elsevier Publishing Co., 365-373 (1993).
85. Sczechowski, J.G.;Koval, C.A. and Noble, R.D., "*Improved Photoefficiencies for TiO₂ Photocatalytic Reactors Through the Use of Controlled Periodic Illumination*", **Photocatalytic Purification and Treatment of Water and Air**, D.F. Ollis and H. Al-Ekabi, editors, Elsevier Publishing Co., 645-650 (1993).
86. Sczechowski, J.G.;Koval, C.A. and Noble, R.D., "*Evidence of Critical Illumination and Dark Recovery Times for Increasing the Photoefficiency in Aqueous Heterogeneous Photocatalysis*", **Journal of Photochemistry and Photobiology, A:Chem.**, **74**, 273-278 (1993).
87. Wan, C.;Noble, R.D. and Clark, N.A., "*Use of Polar Solvents in an Electroconvective Liquid Membrane for Gas Separation*", **Journal of Membrane Science**, **84**, 191-196 (1993).
88. Pellegrino, J.J;Wang, D.;Rabago, R.;Noble, R.D. and Koval, C.A., "*Gas Transport Properties of Solution-Cast Perfluorosulfonic Acid Ionomer Films Containing Ionic Surfactants*", **Journal of Membrane Science**, **84**, 161-169 (1993).
89. Koval, C.A.;Thoen, P. and Noble, R.D., "*Unexpectedly Large Selectivities for Olefin Separations Utilizing Silver Ion in Ion-Exchange Membranes*", **Journal of Physical Chemistry**, **98**, 1262-1269 (1994).
90. Rabago, R. Noble, R.D. and Koval, C.A., "*Effects of Incorporation of Fluorocarbon and Hydrocarbon Surfactants into Perfluorosulfonic Acid (Nafion) Membranes*", **Chemistry of Materials**, **6**, 947-951 (1994).
91. Jia, M-D, Chen, B., Noble, R.D. and Falconer, J.L., "*Ceramic-Zeolite Composite Membranes and their Application for Separation of Vapor/Gas Mixtures*", **Journal of Membrane Science**, **90**, 1-10 (1994).

92. Jacoby, W.A., Nimlos, M.R., Blake, D.M., Noble, R.D. and Koval, C.A., "*Products, Intermediates, Mass Balances, and Reaction Pathways for the Oxidation of Trichloroethylene in Air via Heterogeneous Photocatalysis*", **Environmental Science and Technology**, **28**, 1661-1668 (1994).
93. Moganti, S.; Noble, R.D. and Koval, C.A., "*Analysis of a Membrane/Distillation Column Hybrid Process*", **Journal of Membrane Science**, **93**(1), 31-44(1994).
94. Park, C.S.; Clark, N.A. and Noble, R.D., "*Giant Field-Induced Deformation of Nematic Liquid Crystal Drops*", **Physical Review Letters**, **72** (12), 1838-1841(1994).
95. Jacoby, W.A.; Nimlos, M.R.; Blake, D.M.; Noble, R.D. and Koval, C.A., "*Kinetics of the Oxidation of Trichloroethylene in Air via Heterogeneous Photocatalysis*", **Journal of Catalysis**, **157**, 87-96 (1995).
96. Foster, N.S.; Lancaster, A.N.; Noble, R.D. and Koval, C.A., "*The Effect of Organic Hole Scavenger on the Photodeposition of Copper in Titanium Dioxide Aqueous Suspensions*", **Industrial & Engineering Chemistry Research**, **34**, 3865-3871 (1995).
97. Bai, C.; Jia, M-D; Falconer, J.L.; and Noble, R.D., "*Preparation and Separation Properties of Silicalite Composite Membranes*", **Journal of Membrane Science**, **105**(1/2), 79-87 (1995).
98. Collins, J.P.; Noble, R.D.; Park, C.H. and Clark, N.A., "*Continued Studies of an Electroconvective Liquid Membrane for Gas Separation*", **Journal of Membrane Science**, **99**, 249-257 (1995).
99. Stephan, W.; Noble, R.D. and Koval, C.A., "*Design Methodology for a Membrane/Distillation Column Hybrid Process*", **Journal of Membrane Science**, **99**, 259-272 (1995).
100. Terry, P.A.; Walls, H.J.; Noble, R.D. and Koval, C.A., "*Electrochemically Modulated Complexation Process for Gas Removal and Concentration*", **AIChE Journal**, **41** (12), 2556-2564 (1995).
101. Gokhale, Y.V.; Noble, R.D. and Falconer, J.L., "*Effects of Reactant Loss and Membrane Selectivity on a Dehydrogenation Reaction in a Membrane-Enclosed Catalytic Reactor*", **Journal of Membrane Science**, **103**, 235-242 (1995).
102. Liu, Q.; Rogut, J.; Falconer, J.L. and Noble, R.D., "*Improved Conversion of CH₄ to CH₃OH in a Non-Isothermal Reactor*", **Fuel**, **75** (15), 1748-1754 (1996).
103. Yamaguchi, T.; Boetje, L.M.; Koval, C.A.; Noble, R.D. and Bowman, C.N., "*Transport Properties of Carbon Dioxide Through Amine Functionalized Carrier Membranes*" **Industrial and Engineering Chemistry Research**, **34**, 4071-4077 (1995).
104. Yamaguchi, T.; Koval, C.A.; Noble, R.D. and Bowman, C.N., "*Transport Mechanism of Carbon Dioxide through Amine Functionalized Ion-Exchange Membranes*" **Chemical Engineering Science**, **51**(21), 4781-4789 (1996).
105. Yamaguchi, T.; Baertsch, C.D.; Koval, C.A.; Noble, R.D. and Bowman, C.N., "*Olefin Separation Using Silver Impregnated Ion-Exchange Membranes and Silver Salt/Polymer Blend Membranes*" **Journal of Membrane Science**, **117**, 151-162 (1996).

106. Sczechowski, J.G.; Koval, C.A. and Noble, R.D., "A Taylor Vortex Reactor for Heterogeneous Photocatalysis", **Chemical Engineering Science**, **50**, 20, 3163-3173 (1995).
107. Rabago, R.; Koval, C.A. and Noble, R.D., "Evidence for Parallel Pathways in the Facilitated Transport of Alkenes Through Ag⁺-Exchanged Nafion Films", **Industrial and Engineering Chemistry Research**, **35** (4), 1090-1096 (1996).
108. Smahhi, M.; Jermouni, T.; Marignan, J. and Noble, R.D., "Organic-Inorganic Gas Separation Membranes: Preparation and Characterization" **Journal of Membrane Science**, **116** (2), 211-220 (1996).
109. Liu, Q.; Noble, R.D. and Falconer, J.L., "Organics/Water Separation by Pervaporation with a Zeolite Membrane" **Journal of Membrane Science**, **117**, 163-174 (1996).
110. Funke, H.H.; Falconer, J.L. and Noble, R.D., "Separation of Hydrocarbon Isomer Vapors With Silicalite Zeolite Membranes" **Industrial and Engineering Chemistry Research**, **35**, 1575-1582 (1996).
111. Noble, R.D. and Falconer, J.L., "Silicalite-1 Composite Membranes", **Catalysis Today**, **25**, 209-212 (1995).
112. Pettersen, T.; Argo, A.; Noble, R.D. and Koval, C.A., "Design of Combined Membrane and Distillation Processes", **Separations Technology**, **6**, 175-187 (1996).
113. Foster, N.S.; Koval, C.A.; Sczechowski, J.G. and Noble, R.D., "Investigation of Controlled Periodic Illumination Effects on Photooxidation Processes at Titanium Dioxide Films Using Rotating Ring Disk Photoelectrochemistry" **Journal of ElectroAnalytical Chemistry**, **406**, 213-217 (1996).
114. Koval, C.A.; Bryant, D.L.; Engelhardt, H.; Manley, D.; Rabago, R.; Thoen, P. and Noble, R.D., "Facilitated Transport of Unsaturated Hydrocarbons in Perfluorosulfonic Acid (Nafion) Membranes", **Chemical Separations with Liquid Membranes**, **ACS Symposium Series No. 642**, R.A. Bartsch and J.D. Way, editors, Chapter 20, 286-302 (1996).
115. Manley, D.S.; Williamson, D.L.; Noble, R.D. and Koval, C.A., "Morphological Changes and Facilitated Transport Characteristics for Nafion Membranes of Various Equivalent Weights", **Chemistry of Materials**, **8** (11), 2595-2600 (1996).
116. Funke, H.H.; Argo, A.M.; Baertsch, C.D.; Falconer, J.L. and Noble, R.D., "Separation of Close Boiling Hydrocarbons with Silicalite Zeolite Membranes", **Journal of Chemical Society-Faraday Transactions**, **92** (13) 2499-2502 (1996).
117. Baertsch, C.D.; Funke, H.H.; Falconer, J.L. and Noble, R.D., "Permeation of Aromatic Hydrocarbon Vapors Through Silicalite-Zeolite Membranes", **Journal of Physical Chemistry**, **100**, 7676-7679 (1996).
118. Smetana, J.F.; Falconer, J.L. and Noble, R.D., "Separation of Methyl Ethyl Ketone from Water by Pervaporation Using a Silicalite Membrane", **Journal of Membrane Science**, **114**, 127-130 (1996).
119. Terry, P.A.; Noble, R.D.; Swanson, D. and Koval, C.A., "Electrochemically Modulated Complexation Process for Ethylene/Ethane Separation", **AIChE Journal**, **43** (7), 1709-1716 (1997).

120. Kohls, S.L.; Noble, R.D. and Koval, C.A., “*Effects of Molecular Structure and Equivalent Weight on Facilitated Transport of Alkenes in Ag(I)-PFSI Membranes*”, **Journal of Membrane Science**, **125** (1) 61-73 (1997).
121. Bryant, D.L.; Noble, R.D. and Koval, C.A., “*Facilitated Transport Separation of Benzene and Cyclohexane with Polyvinyl AgNO₃ Membranes*”, **Journal of Membrane Science**, **127** (2) 161-170 (1997).
122. Suzuki, T.; Noble, R.D. and Koval, C.A., “*Electrochemistry, Stability and Alkene Complexation Chemistry for Copper (I) Triflate in Aqueous Solution. Potential for Use in Electrochemically Modulated Complexation Based Separation Processes*”, **Inorganic Chemistry**, **36** (2), 136-140 (1997).
123. Funke, H.H.; Argo, A.M.; Falconer, J.L. and Noble, R.D., “*Separations of Cyclic, Branched, and Linear Hydrocarbon Mixtures Through Silicalite Membranes*”, **Industrial and Engineering Chemistry Research**, **36** (1), 137-143 (1997).
124. Park, C.S.; Clark, N.A. and Noble, R.D., “*A Convective Turbulent State that Spatially Orders Upon Increased Drive*”, **Physics of Fluids**, **17** 055101 (2005).
125. Thunhorst, K.; Bowman, C.N. and Noble, R.D., “*Transport of Ionic Species Through Functionalized Poly (vinyl benzyl chloride) Polymer Membranes*”, **Journal of Membrane Science**, **128**, 183-193 (1997).
126. Funke, H.H.; Frender, K.R.; Green, K.M.; Wilwerding, J.L.; Sweitzer, B.A.; Falconer, J.L. and Noble, R.D., “*Influence of Adsorbed Molecules on the Permeation Properties of Silicalite Membranes*”, **Journal of Membrane Science**, **129**, 77-82 (1997).
127. Coronas, J.; Falconer, J.L. and Noble, R.D., “*Preparation, Characterization and Permeation Properties of Tubular ZSM-5 Composite Membranes*”, **AIChE Journal**, **43** (7), 1797-1812 (1997).
128. Thunhorst, K.L.; Noble, R.D. and Bowman, C.N., “*Preparation of Functionalized Polymers by Reactions of Poly(vinylbenzyl chloride)*”, **Polymer Modification**, C.E. Carraher, G. Swift, and C.N. Bowman, Editors, Plenum Publishing, New York, NY, 97 (1997).
129. Longin, T.L.; Koval, C.A. and Noble, R.D., “*Photomodulation and Photopumping in Membranes Containing Carriers Optimized for Facilitated Transport in the Dark*”, **Journal of Physical Chemistry**, **101** 7172-7179 (1997).
130. Longin, T.L.; Koval, C.A. and Noble, R.D., “*Photomodulation of Transport Rates in Liquid Membranes Containing Photoactive Carriers*”, **Journal of Physical Chemistry**, **101**, 1036-1052 (1998).
131. Burch, J.M.; Denton, J.R. and Noble, R.D., “*Physiologic Rationale for Abbreviated Laparotomy*”, **Surgical Clinics of North America**, **77** (4) 779-782 (1997).
132. Coronas, J.; Noble, R.D. and Falconer, J.L., “*Separations of C₄ and C₆ Isomers in ZSM-5 Tubular Membranes*”, **Industrial and Engineering Chemistry Research**, **36**,166 (1998).
133. Longin, T.L.; Koval, C.A. and Noble, R.D., “*Photopumping in Liquid Membranes Containing Photoactive Carriers*”, **Journal of Physical Chemistry**, **102**, 2064-2075 (1998).
134. Goering, R.M.; Bowman, C.N.; Koval, C.A. and Noble, R.D., “*Role of Ion-Exchange Membrane Morphology and Sorption Properties on Facilitated*

- Transport Di-Olefin/Mono-Olefin Separations*”, **Journal of Membrane Science**, **144**, 133-143 (1998).
135. Goering, R.M.; Bowman, C.N.; Koval, C.A.; Noble, R.D and Ashley, M.E., “*Complexation Structure and Transport Mechanism of 1,5-Hexadiene and 1-Hexene Through Silver Facilitated Transport Membranes*”, **Journal of Membrane Science**, **172**, 49-58 (2000).
 136. Koval, C.A.; Bryant, D.L.; Roberts, S.L. and Noble, R.D., “*Poly(vinyl alcohol)-Silver Nitrate Facilitated Transport Membranes for the Separation of Aromatic and Aliphatic Compounds*”, **Polymer Membranes for Gas and Vapor Separation: Chemistry and Materials Science**, editors: B.D. Freeman and I. Pinnau, Oxford Press, Chapter 10, 127-134 (1999).
 137. Poshusta, J.C.; Vu, T.A.; Falconer, J.L. and Noble, R.D., “*Synthesis and Permeation Properties of SAPO-34 Tubular Membranes*”, **I&EC Research**, **37** (10), 3924-3929 (1998).
 138. Buechler, K.J.; Noble, R.D.; Koval, C.A. and Jacoby, W.A., “*Investigation of the Effects of Controlled Periodic Illumination on the Oxidation of Gaseous TCE using a Thin Film of TiO₂*”, **I&EC Research**, **38**, 892-896 (1999).
 139. Joly, C.; Smaïhi, M.; Porcar, L. and Noble, R.D. “*Polyimide-Silica Composite Materials : How does Silica influence their Microstructure and Gas Permeation Properties?*”, **Chemistry of Materials**, **11**(9), 2331-2338 (1999).
 140. Lin, X.; Falconer, J.L. and Noble, R.D., “*Parallel Pathways for Transport in ZSM-5 Zeolite Membranes*”, **Chemistry of Materials**, **10** (11), 3716-3723 (1998).
 141. Thunhorst, K.; Noble, R.D. and Bowman, C.N., “*Properties of the Transport of Alkali Metal Salts through Polymeric Membranes Containing Benzo-18-Crown-6 Crown Ether Functional Groups*”, **Journal of Membrane Science**, **156**, 293-302 (1999).
 142. Bennett, K.H.; Cook, K.D.; Falconer, J.L. and Noble, R.D., “*Time-Dependent Permeance of Gas Mixtures Through Zeolite Membranes*”, **Analytical Chemistry**, **71**, 1016-1020 (1999).
 143. Buechler, K.J.; Noble, R.D.; Koval, C.A.; Zawistowski, T.M. and Nam, C.H., “*Design and Evaluation of a Novel Controlled Periodic Illumination Reactor to Study Photocatalysis*”, **I&EC Research**, **38**, 1258-1263 (1999).
 144. Gump, C.J.; Noble, R.D. and Falconer, J.L., “*Separation of Hexane Isomers through Nonzeolite Pores in ZSM-5 Zeolite Membranes*”, **I&EC Research**, **38**, 2775-2781 (1999).
 145. Tuan, V.A.; Falconer, J.L. and Noble, R.D., “*Alkali-free ZSM-5 Membranes: Preparation Conditions and Separation Performance*”, **I&EC Research**, **38** 3635-3646 (1999).
 146. Poshusta, J. C., Falconer, J.L. and Noble, R.D., “*Temperature and Pressure Effects on CO₂ and CH₄ Permeation through MFI Zeolite Membranes*”, **Journal of Membrane Science**, **160**:(1) 115-125 (1999).
 147. Poshusta, J.C.; Tuan, V.A.; Pape, E.A.; Noble, R.D. and Falconer, J.L., “*Separation of Light Gas Mixtures Using SAPO-34 Membranes*”, **AIChE Journal**, **46** (4), 779-789 (2000).

148. Tuan, V.A.; Noble, R.D. and Falconer, J.L., “*Boron- Substituted ZSM-5 Membranes: Preparation and Separation Performance*”, **AIChE Journal**, **46(6)**, 1201-1208 (2000).
149. Roberts, S.L.; Noble, R.D. and Koval, C.A., “*Strategy for Selection of Composite Membrane Materials*”, **Industrial and Engineering Chemistry Research**, **39(6)**, 1673-1682 (2000).
150. Gump, C.J.; Lin, X.; Falconer, J.L. and Noble, R.D., “*Experimental Configuration and Adsorption Effects on the Permeation of C₄ Isomers through ZSM-5 Zeolite Membranes*”, **Journal of Membrane Science**, **173 (1)**, 35-52 (2000).
151. Buechler, K.J.; Zawistowski, T.M.; Noble, R.D. and Koval, C.A., “*Investigation of the Mechanism for the Controlled Periodic Illumination Effect in TiO₂ Photocatalysis*”, **Industrial and Engineering Chemistry Research**, **40 (4)**, 1097-1102 (2001).
152. Aoki, K.; Tuan, V.A.; Falconer, J.L. and Noble, R.D., “*Gas Permeation Properties of Ion-Exchanged ZSM-5 Zeolite Membranes*”, **Microporous and Mesoporous Materials**, **39**, 485-492 (2000).
153. Tuan, V.A.; Falconer, J.L. and Noble, R.D., “*Isomorphous Substitution of Al, Fe, B, and Ge into MFI-Zeolite Membranes*”, **Microporous and Mesoporous Materials**, **41**, 269-280 (2000).
154. Flanders, C.L.; Tuan, V.A.; Noble, R.D. and Falconer, J.L., “*Separation of C₆ Isomers by Vapor Permeation and Pervaporation Through ZSM-5 Membranes*”, **Journal of Membrane Science**, **176 (1)**, 43-54 (2000).
155. Poshusta, J.C.; Noble, R.D., and Falconer, J.L., “*Characterization of SAPO-34 Membranes by Water Adsorption*”, **Journal of Membrane Science**, **186 (1)**, 25-40 (2001).
156. Koval, C.A.; Kaljevic, L. and Noble, R.D., “*Polymeric Membrane Materials as Ligands for Ag(I) Ions: Design and Use for Hydrocarbon Separation*”, **Macromolecular Symposia**, **156**, 37-44 (2000).
157. Bennett, K.H.; Cook, K.D.; Falconer, J.L. and Noble, R.D., “*Expanding Simultaneous Process Mass Spectrometric Analysis*”, **J. Process Anal. Chem.**, **5**, 42-49 (2000).
158. Gump, C.J.; Tuan, V.A.; Noble, R.D. and Falconer, J.L., “*Aromatic Permeation through Crystalline Molecular Sieve Membranes*”, **Industrial and Engineering Chemistry Research**, **40 (2)**, 565-577 (2001).
159. Tuan, V.A.; Li, S.; Noble, R.D. and Falconer, J.L., “*Preparation and Pervaporation Properties of a MEL Zeolite Membranes*”, **Chemical Communications**, 583-584 (2001).
160. Lee, Y.; Noble, R.D.; Yeom, B-Y; Park, Y-I, and Lee, K-H, “*Analysis of CO₂ Removal by Hollow Fiber Membrane Contactors*”, **Journal of Membrane Science**, **194 (1)**, 57-68 (2001).
161. Li, S.; Tuan, V.A.; Falconer, J.L. and Noble, R.D., “*Separation of 1,3 Propanediol from Glycerol and Glucose using a ZSM-5 Membrane*”, **Journal of Membrane Science**, **191**, 53-59 (2001).
162. Gade, S.K.; Tuan, V.A.; Gump, C.J.; Noble, R.D. and Falconer, J.L., “*Highly Selective Separation of n-Hexane from Branched, Cyclic, and Aromatic Hydrocarbons using B-ZSM-5 Membranes*”, **Chemical Communications**, 601-602 (2001).

163. Li, S.; Tuan, V.A.; Falconer, J.L. and Noble, R.D., “X-Type Zeolite Membranes: Preparation, Characterization and Pervaporation Separation Performance”, **Microporous and Mesoporous Materials**, **53**, 59-70 (2002).
164. Li, S.; Tuan, V.A.; Falconer, J.L. and Noble, R.D., “Separation of 1,3-Propanediol from Aqueous Solutions using Pervaporation through a X-Type Zeolite Membrane”, **Industrial and Engineering Chemistry Research**, **40 (8)**, 1952-1959 (2001).
165. Kumakiri, I.; Nomura, M.; Yamaguchi, T; Nakao, S.; Noble, R.D. and Falconer, J.L., “Preparation of Zeolite Membranes and Methods to Control the Intercrystalline Pore Structure”, **Function & Materials**, **20 (11)**, 48-57 (2000).
166. Li, S.; Tuan, V.A.; Falconer, J.L. and Noble, R.D., “Effects of Zeolite Membrane Structure on the Separation of 1,3-Propanediol from Glycerol and Glucose by Pervaporation”, **Chemistry of Materials**, **13**, 1865-1873 (2001).
167. Tuan, V.A.; Li, S.; Falconer, J.L. and Noble, R.D., “Separating Organics from Water by Pervaporation with Isomorphously-Substituted MFI Zeolite Membranes”, **Journal of Membrane Science**, **196 (1)**, pp 111-123 (2002).
168. Li, S.; Tuan, V.A.; Noble, R.D. and Falconer, J.L., “ZSM-11 Membranes: Characterization and Pervaporation Performance”, **AIChE Journal**, **48 (2)**, 269-278 (2002).
169. Li, S.; Tuan, V.A.; Noble, R.D. and Falconer, J.L., “Pervaporation of Water/THF Mixtures Using Zeolite Membranes”, **Industrial and Engineering Chemistry Research**, **40**, 4577-4585 (2001).
170. Bowen, T.C.; Falconer, J.L.; Noble, R.D.; Skoulidas, A.I. and Sholl, D.S., “A Comparison of Atomistic Simulations and Experimental Measurements of Light Gas Permeation Through Zeolite Membranes”, **Industrial and Engineering Chemistry Research**, **41(6)**, 1641-1650 (2002).
171. Scovazzo, P.; Visser, A.; Davis, James Jr.; Rogers, R.; Koval, C.A.; DuBois, D. and Noble, R. D. “Supported Ionic Liquid Membranes (SILMs) and Facilitated Ionic Liquid Membranes (FILMs)”, **Ionic Liquids : Industrial Applications to Green Chemistry**, American Chemical Society Symposium Series 818, Eds: Robin D. Rogers, Kenneth R. Seddon, 69-87 (2002).
172. Kalipcilar, H.; Falconer, J.L. and Noble, R.D., “Preparation of B-ZSM-5 Membranes on a Monolith Support”, **Journal of Membrane Science**, **194(1)**, 141-144 (2001).
173. Tanaka, K.; Kita, H.; Okamoto, K.; Noble, R.D. and Falconer, J.L., “Isotopic-Transient Permeation Measurements in Steady-State Pervaporation through Polymeric Membranes”, **Journal of Membrane Science**, **197(1,2)** 173-184 (2002).
174. Gardner, T.Q.; Flores, A.I.; Noble, R.D. and Falconer, J.L., “Transient Measurements of Adsorption and Diffusion in H-ZSM-5 Membranes”, **AIChE Journal**, **48(6)** 1155-1167 (2002).
175. Li, S.; Tuan, V.A.; Noble, R.D. and Falconer, J.L., “A Ge-Substituted ZSM-5 Zeolite Membrane for Separation of Acetic Acid from Water”, **Industrial and Engineering Chemistry Research**, **40**, 6165-6171 (2001).
176. Tuan, V.A.; Li, S.; Falconer, J.L. and Noble, R.D., “In-Situ Crystallization of Beta Zeolite Membranes and Their Permeation and Separation Properties”, **Chemistry of Materials**, **14**, 489-492 (2002) .

177. Gardner, T.Q.; Lee, J.B.; Noble, R.D. and Falconer, J.L., “*Adsorption and Diffusion Properties of Butanes in ZSM-5 Zeolite Membranes*”, **Industrial and Engineering Chemistry Research**, **41**, 4094-4105 (2002).
178. Kalipcilar, H.; Gade, S.K.; Noble, R.D. and Falconer, J.L., “*Synthesis and Separation Properties of B-ZSM-5 Zeolite Membranes on Monolith Supports*”, **Journal of Membrane Science**, **210 (1)**, 113-128 (2002).
179. Kalipcilar, H.; Bowen, T.C.; Noble, R.D. and Falconer, J.L., “*Synthesis and Separation Performance of SSZ-13 Zeolite Membranes on Tubular Supports*”, **Chemistry of Materials**, **14**, 3458-3464 (2002).
180. Gardner, T.Q.; Falconer, J.L.; and Noble, R.D. “*Adsorption and Diffusion Properties of Zeolite Membranes by Transient Permeation*”, **Desalination**, **149**, 435-440 (2002).
181. Sommer, S.; Melin, T.; Falconer, J.L. and Noble, R.D., “*Transport of C₆ Isomers through ZSM-5 Zeolite Membranes*”, **Journal of Membrane Science**, **224**, 51-67 (2003).
182. Gardner, T.Q.; Falconer, J.L.; Noble, R.D. and Zieverink, M. “*Analysis of Transient Permeation Fluxes into and out of Membranes for Adsorption Measurements*”, **Chemical Engineering Science**, **58**, 2103-2112 (2003).
183. Bowen, T.C.; Li, S.; Tuan, V.A.; Falconer, J.L. and Noble, R.D. “*Pervaporation of Aqueous Organic Mixtures through Ge-ZSM-5 Zeolite Membranes*”, **Desalination**, **147**, 327-329 (2002).
184. Bowen, T.C.; Kalipcilar, H.; Falconer, J.L. and Noble, R.D. “*Separation of C₄ and C₆ Isomer Mixtures and Alcohol-Water Solutions by Monolith Supported B-ZSM-5 Membranes*”, **Desalination**, **147**, 331-332 (2002).
185. Goyette, M.L.; Longin, T.L.; Noble, R.D. and Koval, C.A., “*Selective Photofacilitated Transport of Sodium Ions Through Liquid Membranes: Key Factors in Experimental Design, Transport Results and Comparison with a Mathematical Model*”, **Journal of Membrane Science**, **212 (1&2)**, 225-235 (2003).
186. Scovazzo, P.; Poshusta, J.; DuBios, D.; Koval, C.A. and Noble, R.D., “*Electrochemical Separation and Concentration of <1% Carbon Dioxide from Nitrogen*”, **Journal of Electrochemical Society**, D91-D98, 150 (2003).
187. Bowen, T.C.; Kalipcilar, H.; Falconer, J.L. and Noble, R.D., “*Pervaporation of Organic/Water Mixtures through B-ZSM-5 Zeolite Membranes on Monolith Supports*”, **Journal of Membrane Science**, **215**, 235-247 (2003).
188. Li, S.; Tuan, V.A.; Falconer, J.L. and Noble, R.D., “*Properties and Separation Performance of Ge-ZSM-5 Membranes*”, **Microporous and Mesoporous Materials**, **58**, 137-154 (2003).
189. Tuan, V.A.; Weber, L.L.; Falconer, J.L. and Noble, R.D., “*Synthesis of novel B-Substituted Beta Zeolite Membrane*”, **Industrial and Engineering Chemistry Research**, **42 (13)** 3019-3021 (2003).
190. Tuan, V.A.; Li, S.; Noble, R.D. and Falconer, J.L., “*MTBE Adsorption on All-Silica Zeolite Beta*”, **Environmental Science and Technology**, **37 (17)** 4007-4010 (2003).
191. Bowen, T.C.; Li, S.; Noble, R.D. and Falconer, J.L., “*Driving Force for Pervaporation through Zeolite Membranes*”, **Journal of Membrane Science**, **225**, 165-176 (2003).

192. Skoulidas, A.I.; Bowen, T.C.; Doelling, C.M.; Falconer, J.L.; Noble, R.D. and Sholl, D.S., “Comparing Atomistic Simulations and Experimental Measurements for CH_4/CF_4 Mixture Permeation Through Silicalite Membranes”, **Journal of Membrane Science**, **227**, 123-136 (2003).
193. Gardner, T.Q.; Falconer, J.L. and Noble, R.D., “Characterization of ZSM-5 and ZSM-11 Zeolite Membranes by Transient Permeation of Butanes”, **AIChE Journal**, **50 (11)**, 2816-2834 (2004).
194. Scovazzo, P.; Camper, D.; Kieft, J. and Noble, R.D., “Regular Solution Theory and CO_2 -Gas Solubility in Room Temperature Ionic Liquids”, **Industrial and Engineering Chemistry Research**, **43**, 6855-6860 (2004).
195. Scovazzo, P.; Kieft, J.; Finan, D.; Noble, R.D. and Koval, C.A., “Gas Separations Using Non-Hexafluorophosphate [PF_6] Anion Supported Ionic Liquid Membranes”, **Journal of Membrane Science**, **238**, 57-64 (2004).
196. Camper, D.; Scovazzo, P. and Noble, R.D., “Gas Solubilities in Room Temperature Ionic Liquids”, **Industrial and Engineering Chemistry Research**, **43 (12)**, 3049-3054 (2004).
197. Li, S.; Falconer, J.L. and Noble, R.D., “SAPO-34 Membranes for CO_2/CH_4 Separations”, **Journal of Membrane Science**, **241**, 121-135 (2004).
198. Li, S.; Alvarado, G.; Noble, R.D. and Falconer, J.L., “Effect of Impurities on CO_2/CH_4 Separation through SAPO-34 Membranes”, **Journal of Membrane Science**, **251**, 59-66 (2005).
199. Bowen, T.C.; Wyss, J.C.; Noble, R.D. and Falconer, J.L., “Inhibition during Multicomponent Diffusion through ZSM-5 Zeolite”, **Industrial and Engineering Chemistry Research**, **43**, 2598-2601 (2004).
200. Bowen, T.C.; Wyss, J.C.; Noble, R.D. and Falconer, J.L., “Measurements of Diffusion through a Zeolite Membrane using Isotopic-Transient Pervaporation”, **Microporous and Mesoporous Materials**, **71**, 199-210 (2004).
201. Bowen, T.C.; Noble, R.D. and Falconer, J.L., “Fundamentals and Applications of Pervaporation through Zeolite Membranes”, **Journal of Membrane Science**, **245**, 1-33 (2004).
202. Shah, M.R.; Noble, R.D. and Clough, D.E., “Pervaporation-Air Stripping Hybrid Process for the Removal of VOCs from Groundwater”, **Journal of Membrane Science**, **241**, 257-263 (2004).
203. Norman, M.; Noble, R.D. and Koval, C.A., “Electrochemical Pumping of DMF Electrolyte Solutions Across Membranes”, **Journal of the Electrochemical Society**, **151 (12)**, E364-E369, (2004).
204. Motuzas, J.; Julbe, A.; Noble, R.D.; Beresnevicius, Z.J. and Cot, D., “Rapid Synthesis of Silicalite-1 Seeds by Microwave Assisted Hydrothermal Treatment”, **Microporous and Mesoporous Materials**, **80**: 73-83 (2005).
205. Camper, D.; Becker, C.; Koval, C.A. and Noble, R.D., “Low Pressure Hydrocarbon Solubility in Room Temperature Ionic Liquids Containing Imidazolium Rings Interpreted using Regular Solution Theory”, **Industrial and Engineering Chemistry Research**, **44**, 1928 (2005).
206. Evans, C.E.; Noble, R.D. and Koval, C.A., “A Nonmechanical Membrane-Based Liquid Pressurization System”, **Industrial and Engineering Chemistry Research**, **45 (1)**, 472 -475, (2006).

207. Li, S.; Martinek, J.G.; Falconer, J.L.; Noble, R.D. and Gardner, T.Q., “*High Pressure CO₂/CH₄ Separation Using SAPO-34 Membranes*”, **Industrial and Engineering Chemistry Research**, **44 (9)**, 3220-3228 (2005).
208. Hong, M.; Falconer, J.L. and Noble, R.D., “*Modification of Zeolite Membranes for H₂ Separation by Catalytic Cracking of Methyl-diethoxysilane*”, **Industrial and Engineering Chemistry Research**, **44(11)**, 4035-4041 (2005).
209. Noble, R.D. and Agrawal, R., “*Separation Research Needs for the 21st Century*”, **Industrial and Engineering Chemistry Research**, **44 (9)**, 2887-2892 (2005).
210. Gin, D.; Zhou, M.; Kidd, T.J. and Noble, R.D., “*Supported Lyotropic Liquid Crystal Polymer Membranes: Promising Materials for Molecular Size-Selective Aqueous Nanofiltration*”, **Advanced Materials**, **Vol. 17, Issue 15**, 1850-1853 (2005).
211. Arruebo, M.; Falconer, J.L. and Noble, R.D., “*Separation of binary C₅ and C₆ hydrocarbon mixtures through MFI zeolite membranes*”, **Journal of Membrane Science**, **269 (1-2)**, 171-176 (2006).
212. Yu, M.; Falconer, J.L. and Noble, R.D., “*Adsorption of Liquid Mixtures on Silicalite-1 Zeolite: a Density-Bottle Method*”, **Langmuir**, **21**, 7390-7397 (2005).
213. Evans, C.E.; Noble, R.D.; Nazari-Thompson, S.; Narazi, B. and Koval, C.A., “*Role of Conditioning on Water Uptake and Hydraulic Permeability of Nafion Membranes*”, **Journal of Membrane Science**, **279**, 521-528 (2006).
214. Motuzas, J.; Julbe, A.; Noble, R.D.; and Beresnevicius, Z.J., “*Rapid Synthesis of Oriented Silicalite-1 Seeds by Microwave Assisted Hydrothermal Treatment*”, **Microporous and Mesoporous Materials**, **92 (1-3)**, 259-269 (2006) .
215. Norman, M.A.; Evans, C.E.; Fuoco, A.R.; Noble, R.D. and Koval, C.A., “*Characterization of a Membrane-based, Electrochemically Driven Pumping System using Aqueous Electrolyte Solutions*”, **Analytical Chemistry**, **77**, 6374-6380 (2005).
216. Camper, D.; Becker, C.; Koval, C.; Noble, R.D., “*Diffusion and Solubility in Room Temperature Ionic Liquids*”, **Industrial and Engineering Chemistry Research**, **45 (1)**, 445-450 (2006).
217. Bara, J.E.; Kaminski, A.K.; Noble, R.D. and Gin, D.L., “*Influence of Nanostructure on Light Gas Separations in Cross-linked Lyotropic Liquid Crystal Membranes*”, **Journal of Membrane Science**, **288 (1-2)**, 13-19 (2007).
218. Shah, M.R.; Noble, R.D. and Clough, D.E., “*Analysis of Transient Permeation as a Technique for Determination of Sorption and Diffusion in Supported Membranes*”, **Journal of Membrane Science**, **280**, 452-460 (2006).
219. Camper, D.; Bara, J.E.; Koval, C.A. and Noble, R.D., “*Bulk Fluid Solubility and Membrane Feasibility of RMIM-based Room Temperature Ionic Liquids*”, **Industrial and Engineering Chemistry Research**, **45**, 6279-6283 (2006).
220. Martinek, J.G.; Gardner, T.Q.; Noble, R.D. and Falconer, J.L., “*Modeling Transient Permeation of Binary Mixtures Through Zeolite Membranes*”, **Industrial and Engineering Chemistry Research**, **45 (17)**, 6032-6043 (2006).
221. Noble, R.D., “*New Materials for Selective Membrane Separations*”, **Makrochimica (Membrane)**, **31 (2)**, (2006).
222. Li, S.; Falconer, J.L. and Noble, R.D., “*Improved SAPO-34 Membranes for CO₂/CH₄ Separations*”, **Advanced Materials**, **18**, 2601-2603 (2006).

223. Yu, M.; Hunter, J.T.; Falconer, J.L. and Noble, R.D., "Adsorption of Benzene Mixtures on Silicalite-1 and NaX Zeolites", **Microporous and Mesoporous Materials**, **96 (1-3)**, 376-385 (2006).
224. Li, S.; Falconer, J.L.; Noble, R.D. and , Krishna, R., "Modeling Permeation of CO_2/CH_4 , CO_2/N_2 , and N_2/CH_4 Mixtures across SAPO-34 Membrane with the Maxwell-Stefan Equations", **Industrial and Engineering Chemistry Research**, **46**, 3904 - 3911 (2007).
225. Hong, M.; Li, S.; Falconer, J.L. and Noble, R.D.; "Ion-Exchanged SAPO-34 Zeolite Crystals and Membranes", **Microporous and Mesoporous Materials**, **106**, 140-146 (2007).
226. Shah, M.R.; Noble, R.D. and Clough, D.E., "Measurement of Sorption and Diffusion in Nonporous Membranes by Transient Permeation Experiments", **Journal of Membrane Science**, **287(1)**, 111-118 (2007).
227. Hong, M.; Li, S.; Falconer, J.L. and Noble, R.D.; "Hydrogen Purification using a SAPO-34 Membrane", **Journal of Membrane Science**, **307**, 277-283 (2008).
228. Yu, M.; Falconer, J.L.; Amundsen, T.J.; Hong, M. and Noble, R.D., "A Controllable Nanosized Valve", **Advanced Materials**, **19 (19)**, 3032-3036 (2007).
229. Jeerage, K.M.; Noble, R.D. and Koval, C.A., "Investigation of an Aqueous Lithium Iodide/Triiodide Electrolyte for Dual-Chamber Electrochemical Actuators", **Sensors and Actuators B, Chemical**, **125**, 180-188 (2007).
230. Li, S.; Li, S.; Falconer, J.L.; Noble, R.D. and , Krishna, R., "Interpreting Unary, Binary and Ternary Mixture Permeation across a SAPO-34 Membrane with Loading Dependent Maxwell-Stefan Diffusivities", **Journal of Physical Chemistry C**, **111**, 5075-5082 (2007).
231. Gardner, T.Q.; Martinek, J.G.; Noble, R.D. and Falconer, J.L., "Enhanced Flux Through Double-Sided Zeolite Membranes", **Journal of Membrane Science**, **304**, 112-117 (2007).
232. Yu, M.; Falconer, J.L.; Noble, R.D. and , Krishna, R., "Modeling Transient Permeation of Polar Organic Mixtures through a MFI Zeolite Membrane using the Maxwell-Stefan Equations", **Journal of Membrane Science**, **293**, 167-173 (2007).
233. Carreon, M.; Li, S.; Falconer, J.L. and Noble, R.D., "SAPO-34 Seeds and Membranes Prepared Using Multiple Templates" **Advanced Materials**, **20**, 729-732 (2008).
234. Li, S.; Falconer, J.L. and Noble, R.D., "SAPO-34 Membranes for CO_2/CH_4 Separations: Effect of Si/Al Ratio", **Microporous and Mesoporous Materials**, **110**, 310-317 (2008).
235. Yu, M., Falconer, J.L., Amundsen, T.J., Hong, M., and Noble, R.D., "Flexible Nanostructure of MFI Zeolite Membranes", **Journal of Membrane Science**, **298**, 182-189 (2007).
236. Finotello, A.; Bara, J.E.; Camper, D. and Noble, R.D., "Room Temperature Ionic Liquids: Temperature Dependence of Gas Solubility Selectivity", **Industrial and Engineering Chemistry Research**, **47(10)**, 3453-3459 (2008).
237. Bara, J. E.; Lessmann, S.; Gabriel, C. J.; Hatakeyama, E.; Noble, R. D.; Gin, D. L. "Synthesis and Performance of Polymerizable Room Temperature Ionic Liquids as Gas Separation Membranes", **Industrial and Engineering Chemistry Research**, **46**, 5397-5404 (2007).

238. Bara, J. E.; Gabriel, C. J.; Lessmann, S.; Carlisle, T. K.; Finotello, A.; Gin, D. L.; Noble, R. D. “*Enhanced CO₂ Separation Selectivity in Oligo(Ethylene Glycol) Functionalized Room Temperature Ionic Liquids*”, **Industrial and Engineering Chemistry Research**, **46**, 5380-5386 (2007).
239. Zhou, M.; Nemade, P.R.; Lu, X. Zeng, X. ; Hatakeyama, E.S. ; Noble, R.D. and Gin, D.L., “*A New Type of Membrane Material for Water Desalination Based on a Cross-Linked Bicontinuous Cubic Lyotropic Liquid Crystal Assembly*”, **Journal of the American Chemical Society**, **129** (31) 9574-9575 (2007).
240. Yu, M.; Wyss, J.C.; Noble, R.D. and Falconer, J.L., “*2,2-Dimethylbutane Adsorption and Diffusion in MFI Zeolite*”, **Microporous and Mesoporous Materials**, **111**, 24-31 (2008).
241. Yu, M.; Li, S.; Falconer, J.L. and Noble, R.D., “*Reversible H₂ Storage using a SAPO-34 Zeolite Layer*”, **Microporous and Mesoporous Materials**, **110**, 579-582 (2008).
242. Bara, J. E.; Hatakeyama, E. S.; Gabriel, C. J.; Lessmann, S.; Gin, D. L.; Noble, R. D. “*Synthesis and Gas Separation Performance of Cross-linked Gemini Room Temperature Ionic Liquid Polymer Membranes*”, **Journal of Membrane Science**, **316**, 186-191 (2008).
243. Finotello, A.; Bara, J.E.; Camper, D. and Noble, R.D., “*Ideal Gas Solubilities and Solubility Selectivities in a Binary Mixture of Ionic Liquids*”, **Journal of Physical Chemistry B**, **112**, 2335-2339 (2008).
244. Gin, D.L.; Bara, J.E.; Noble, R.D. and Elliott, B.J., “*Polymerized Lyotropic Liquid Crystal Assemblies for Membrane Applications*”, **Macromolecular Rapid Communications**, **29** (5), 361-448 (2008).
245. Bara, J. E.; Gabriel, C. J.; Hatakeyama, E. S.; Carlisle, T. K.; Lessmann, S.; Noble, R. D.; Gin, D. L., “*Improving CO₂ Selectivity in Polymerized Room-Temperature Ionic Liquid Gas Separation Membranes through Incorporation of Polar Substituents*”, **Journal of Membrane Science**, **321**, 3-7 (2008).
246. Krishna, R.; Li, S.; van Baten, J.M.; Falconer, J.L. and Noble, R.D., “*Investigation of Slowing Down and Speeding Up Effects in Binary Mixture Permeation Across SAPO-34 and MFI Membranes*”, **Separation and Purification Technology**, **60**, 230-236 (2008).
247. Yu, M.; Li, S.; Falconer, J.L. and Noble, R.D., “*Characterizing Non-Zeolite Pore Volume by Temperature-Programmed Desorption*”, **Microporous and Mesoporous Materials**, **113** (1-3) 224-230 (2008).
248. Lee, J.B.; Funke, H.; Noble, R.D. and Falconer, J.L., “*High Selectivities in Defective MFI Membranes*”, **Journal of Membrane Science**, **321**, 309-315 (2008).
249. Bara, J. E.; Hatakeyama, E.S.; Gin, D.L. and Noble, R.D., “*Improving CO₂ Permeability in Polymerized Room-Temperature Ionic Liquid Gas Separation Membranes through the Formation of a Solid Composite with a Room-Temperature Ionic Liquid*”, **Polymers for Advanced Technologies**, **19**, 1415-1420 (2008).
250. Carlisle, T.K.; Bara, J.E.; Noble, R.D. and Gin, D.L., “*Interpretation of CO₂ Solubility and Selectivity in Nitrile-Functionalized Room-Temperature Ionic Liquids Using a Group Contribution Approach*”, **Industrial and Engineering Chemistry Research**, **47** (18), 7005-7012 (2008).

251. Yu, M.; Li, S.; Falconer, J.L. and Noble, R.D., “*High Density, Vertically-Aligned Carbon Nanotube Membranes with High Fluxes*”, **Nano Letters**, **9 (1)** 225-229 (2009).
252. Carreon, M.A.; Li, S.; Falconer, J.L. and Noble, R.D., “*Alumina SAPO-34 Membranes for CO₂/CH₄ Separations*”, **Journal of American Chemical Society**, **130 (16)** 5412- (2008).
253. Li, S.; Carreon, M.A.; Funke, H.F.; Noble, R.D. and Falconer, J.L., “*Scale Up of SAPO-34 Membranes for CO₂/CH₄ Separation*”, **Journal of Membrane Science**, in press.
254. Sorenson, S.G.; Smyth, J.R.; Kocirik, M.; Zikanova, A.; Noble, R.D. and Falconer, J.L., “*Adsorbate-Induced Expansion of MFI Zeolite Crystals*”, **Industrial and Engineering Chemistry Research**, **47(23)** 9611-9616 (2008).
255. Bara, J.E.; Gabriel, C.J.; Carlisle, T.K.; Camper, D.E.; Finotello, A.; Gin, D.L. and Noble, R.D., “*Gas Separations in Fluoroalkyl-functionalized Room-Temperature Ionic Liquids Using Supported Liquid Membranes*”, **Chemical Engineering Journal**, **147**, 43-50 (2009).
256. Bara, J.E.; Gin, D.L. and Noble, R.D., “*Effect of Anion on Gas Separation Performance of Polymer Room Temperature Ionic Liquid Composite Membranes*”, **Industrial and Engineering Chemistry Research**, **47(24)** 9919-9924 (2008).
257. Yu, M.; Falconer, J.L. and Noble, R.D., “*Characterizing Nonzeolite Pores in MFI Membranes*”, **Industrial and Engineering Chemistry Research**, **47(11)** 3943-3948 (2008).
258. Camper, D.; Bara, J.E.; Gin, D.L. and Noble, R.D., “*Room Temperature Ionic Liquids-Amine Solutions: Tunable Solvents for Efficient and Reversible Capture of CO₂*”, **Industrial and Engineering Chemistry Research**, **47 (21)**, 8496-8498 (2008).
259. Hatakeyama, E.S.; Ju, H.; Gabriel, C.J.; Lohr, J.L.; Bara, J.E.; Noble, R.D.; Freeman, B.D. and Gin, D.L., “*New Protein Resistant Coatings for Water Filtration Membranes Based on Quaternary Ammonium and Phosponium Polymers*”, **Journal of Membrane Science**, **330(1-2)** 104-116 (2009).
260. Bara, J.E.; Carlisle, T.K.; Gabriel, C.J.; Camper, D.; Finotello, A.; Gin, D.L. and Noble, R.D., “*A Guide to CO₂ Separations in Imidazolium-based Room-Temperature Ionic Liquids*”, **Industrial and Engineering Chemistry Research**, **48(6)** 2739-2751 (2009).
261. Carreon, M.A.; Li, S.G.; Falconer, J.L. and Noble, R.D., “*SAPO-34 seeds and membranes prepared using multiple structure directing agents*”, **Advanced Materials**, **20 (4)**, 729 - 732 , (2008).
262. LaFrate, A.L.; Bara, J.E.; Gin, D.L. and Noble, R.D., “*Synthesis of Diol-functionalized Imidazolium-based Room-Temperature Ionic Liquids with Bis(trifluoromethanesulfonimide) Anions that Exhibit Switchable Water Miscibility*” **Industrial and Engineering Chemistry Research**, **48 (18)** 8757-8759 (2009).
263. Tokay, B.; Falconer, J.L. and Noble, R.D., “*Alcohol and Water Adsorption and Capillary Condensation in MFI Zeolite Membranes*” **Journal of Membrane Science**, **334** 23-29 (2009).

264. Avila, A.M.; Funke, H.H.; Zhang, Y.; Falconer, J.L. and Noble, R.D., “Concentration Polarization in SAPO-34 Membranes at High Pressure”, **Journal of Membrane Science**, **335(1-2)** 32-36 (2009).
265. Bara, J.E.; Noble, R.D. and Gin, D.L., “Effect of “Free” Cation Substituent on Gas Separation Performance of Polymer—Room-Temperature Ionic Liquid Composite Membranes”, **Industrial and Engineering Chemistry Research**, **48(9)** 4607-4610 (2009).
266. Lee, J.B.; Funke, H.H.; Noble, R.D. and Falconer, J.L., “Adsorption-Induced Expansion of Defects in MFI Membranes”, **Journal of Membrane Science**, **341(1-2)** 238-245 (2009).
267. Soydas, B.; Funke, H.H.; Zhang, Y.; Falconer, J.L. and Noble, R.D., “Selective Zeolite A Membranes Due to Water-Induced Water Swelling”, **Journal of Membrane Science**, submitted for publication.
268. Voss, B.A.; Bara, J.E.; Gin, D.L. and Noble, R.D., “Physically Gelled Ionic Liquid Membranes with Enhanced CO₂ Gas Transport”, **Chemistry of Materials**, **21(14)** 3027-3029 (2009).
269. Bara, J.E.; Camper, D.E.; Gin, D.L. and Noble, R.D., “Room-Temperature Ionic Liquids and Composite Materials: Platform Technologies for CO₂ Capture”, **Accounts of Chemical Research**, in press.
270. Sorenson, S.G.; Smyth, J.R.; Noble, R.D. and Falconer, J.L., “Correlation of Silicalite-1 Crystal Expansion and MFI Membrane Properties”, **Industrial and Engineering Chemistry Research**, **48(22)** 10021-10024 (2009).
271. Hudiono, Y.C.; Carlisle, T.K.; Bara, J.E.; Zhang, Y.; Gin, D.L. and Noble, R.D., “A Three-Component Mixed-Matrix Membrane with Enhanced CO₂ Separation Properties Based on Zeolites and Ionic Liquid Materials” **Journal of Membrane Science**, **350(1)** 117-123 (2010).
272. Gibbons, W.T.; Zhang, Y.; Falconer, J.L. and Noble, R.D., “Inhibiting Crystal Swelling in MFI Zeolite Membranes”, **Journal of Membrane Science**, **357**, 54-61 (2010).
273. Yu, M.; Funke, H.H.; Noble, R.D. and Falconer, J.L., “Gated Ion Transport through Dense Carbon Nanotube Membranes”, **Journal of the American Chemistry Society** **132**, 8285-8290 (2010).
274. Jin, Y.; Voss, B.; Noble, R.D. and Zhang, W., “Shape-Persistent Organic Prismatic Molecular Cage with High Selectivity in Adsorption of CO₂ over N₂” **Angewandte Chemie**, in press.
275. Zhang, Y.; Avila, A.M.; Tokay, B.; Funke, H.H.; Falconer, J.L. and Noble, R.D., “Blocking Defects in SAPO-34 Membranes with Cyclodextrin”, **Journal of Membrane Science**, in press.
276. Simons, K.; Niemeijer, K.; Bara, J.E.; Noble, R.D. and Wessling, M., “How do polymerized room-temperature ionic liquid membranes plasticize during high pressure CO₂ permeation?” **Journal of Membrane Science**, in press.
277. LaFrate, A.L.; Gin, D.L. and Noble, R.D., “High Water Vapor Flux Membranes Based on Novel Diol-Imidazolium Polymers”, **Industrial and Engineering Chemistry Research**, in press.

278. Bara, J.E.; Hatakeyama, E.S.; Zeng, X.; Noble, R.D. and Gin, D.L., “*Thermotropic Liquid Crystal Behavior of Gemini Imidazolium-Based Amphiphiles*”, **Liquid Crystals**, submitted for publication.
279. Sorenson, S. G., Payzant, E. A., Noble, R. D., Falconer, J. L., "Influence of crystal expansion/contraction on zeolite membrane permeation," **Journal of Membrane Science** **357**, 98-104 (2010).
280. Hatakeyama, E.S.; Wiesenauer, B.R.; Gabriel, C.J.; Lohr, J.L.; Zhou, M.; Noble, R.D.; Gin, D.L. "Water Filtration Performance of a Lyotropic Liquid Crystal Polymer Membrane with Uniform, Sub-1-nanometer Pores", **Journal of Membrane Science**, submitted for publication.
281. Zhang, Y.; Tokay, B.; Funke, H.H.; Falconer, J.L. and Noble, R.D., “*Template Removal from SAPO-34 Crystals and Membranes*”, **Journal of Membrane Science**, submitted for publication.
282. Hatakeyama, E.S.; Wiesenauer, B.R.; Gabriel, Noble, R.D.; Gin, D.L. " Nanoporous, Bicontinuous Cubic Lyotropic Liquid Crystal Networks via Polymerizable Gemini Ammonium Surfactants", **Chemistry of Materials**, **22**, 4525-4527 (2010).
283. Yu, M.; Funke, H.H.; Noble, R.D.; Falconer, J.L., “*H₂ Separation using Ultrathin Microporous Al₂O₃ Supported by SAPO-34 Membranes*”, **Advanced Materials**, submitted for publication.
284. Carlisle, T.K.; Bara, J.E.; LaFrate, A.L.; Gin, D.L. Noble, R.D., “*Main-Chain Imidazolium Polymer Membranes for CO₂ Separations: An Initial Study of New Ionic Liquid-Inspired Platform*”, **Journal of Membrane Science**, **359**, 37-43 (2010).
285. Smith, G.D.; Borodin, O.; Magda, J.J.; Boyd, R.H.; Wang, Y.S.; Bara, J.E.; Miller, S.; Gin, D.L.; Noble, R.D., “*A Comparison of Fluoro-derivatized Imidazolium: TFSI and Alkyl-derivatized Imidazolium: TFSI Ionic Liquids: A Case Study*”, **Physical Chemistry Chemical Physics** **12(26)**, 7064-7076 (2010).
286. Hudiono, Y.C., Carlisle, T.K., LaFrate, A.L., Gin, D.L., Noble, R.D., “*Novel Mixed Matrix Membranes Based on Polymerizable Room-Temperature Ionic Liquids and SAPO-34 Particles to Improve CO₂ Separation*”, **Journal of Membrane Science**, submitted for publication.
287. Sorenson, S.G., Payzant, E.A., Gibbons, W.T., Soydas, B., Kita, H., Noble, R.D., Falconer, J.L. “*Influence of Zeolite Crystal Expansion/Contraction on NaA Zeolite Membrane Separations*”, **Journal of Membrane Science**, submitted for publication.

Educational Publications

1. "Freeze Drying Fruits and Vegetables - A Laboratory Experiment," **Chemical Engineering Education** 142-144 (Summer, 1979).
2. "The Use of Relaxation in Overcoming Anxiety in Problem Solving," **Engineering Education**, co-authored with Susan Richardson and Michael Hawkins, 158-159 (November, 1980).
3. "Units and Dimensions," Module 1: Series F: Material and Energy Balances **Chemical Engineering Modular Instruction Project 1**, 1-4 (1981).

4. "*Temperature (Measurement, Scales, Conversion)*," Module 4: Series F: Material and Energy Balances, co-authored with Richard L. Zelenka, **Chemical Engineering Modular Instruction Project 1**, 5-9 (1981).
5. "*Pressure (Measurement, Scales, Conversion)*," Module 5: Series F: Material and Energy Balances Section, co-authored with Gerald Boydston, **Chemical Engineering Modular Instruction Project 1**, 10-15 (1981).
6. "*Real Gas Mixtures*," Module 7: Series F: **Chemical Engineering Modular Instruction Project 1**, 33-40 (1981).
7. "*Steady-State Material Balance - Recycle, Bypass, Purge*," Module 7: Series F: Material and Energy Balances, **Chemical Engineering Modular Instruction Project 2**, 37-42 (1981).
8. "*Awards as Lasting Rewards*," **Engineering Education 72**: 5, 387 (February, 1982).
9. "*Natural Convection*," Module 4: Series C: Transport Section, **Chemical Engineering Modular Instruction Project 4**, 20-28 (1983).
10. "*Differential Energy Balance*," Module 6: Series C: Transport, **Chemical Engineering Modular Instruction Project 4**, 41-47 (1983).
11. "*Solar Hot Water Heating by Natural Convection*," **Chemical Engineering Education**, 20-23 (Winter, 1983).
12. "*Laboratory Experiment for the Transient Response of a Stirred Vessel*," R.D. Noble, R.G. Jacquot, and L.B. Baldwin, **Chemical Engineering Education**, 70-72 (Spring 1983).
13. "*Putting Problem Solving to Use in the Classroom*," **Chemical Engineering Education**, 134-137 (Summer, 1983).
14. "*Adjunct Position: One Way to Keep Up with Technology and Education*," **Chemical Engineering Education** 162-163 (Summer, 1985).

Grants

1. "*Thermal Decomposition of Kerogen Under Elevated Pressure*," co-principal investigator with H. Gordon Harris, U.S. Department of Energy, **Laramie Energy Research Center** through RMIEE. Received **\$9,800** May 15 - August 15, 1977. First Year - September 1977 - August 31, 1978, **\$68,459**. Renewed October 1, 1978 - August 31, 1980, **\$77,986**.
2. "*Effect of Toxic Metal Addition on O₂ Uptake Rate in Activated Sludge-PAC Systems*," co-principal investigator with D. Foster. Awarded through **Wyoming Mining and Mineral Resources and Research Institute**, **\$4,500**, May - September 1979.
3. "*Modeling of River Water Temperatures*," awarded through **Wyoming Mining and Mineral Resources and Research Institute**, **\$2,600**, May - August 1980.
4. "*Acid Gas Separation Using Chemical Complexation in Ion Exchange Membranes*," co-principal investigator with J.D. Way, **U.S. Department of Energy**, Advanced Gasification Projects, 2 years, **\$295,779**, May 1984 - April 1986.
5. "*Organic and Heavy Metal Extraction from Aqueous Streams Using Emulsion Liquid Membranes*," co-principal investigator with A.L. Bunge, **U.S. Environmental Protection Agency**, **\$180,000**, June 1984 - June 1986.

6. "*Electro and Photofacilitated Transport of Molecules through Liquid Membranes*," co-principal investigator with C.A. Koval, **National Science Foundation, \$29,870**, December 1985 - December 1986.
7. "*Membranes Separations for Hydrogen Production*," co-principal investigator with J.D. Way, **U.S. Department of Energy**, Advanced Gasification Projects, **\$700,358**, May 1986 - April 1989.
8. "*Bioartificial Pancreas*," **NATO Travel Grant, \$5,060**, March 1987 - March 1990.
9. "*Performance of Ceramic Membranes*," **Alcan International, \$40,945**, February 1988 - January 1989.
10. "*High Temperature Catalytic Processes with Ceramic Membranes*," **Advanced Materials Institute**, co-principal investigator with J. Falconer, **\$5000**, January 1988 - August 1988.
11. "*New Electrochemical Processes for the Removal of Heterocyclic Organic Compounds from Hydrocarbon Phases*," co-principal investigator with C.A. Koval, **National Science Foundation, \$160,000**, June 1988 - May 1990.
12. "*Indirect Electrolysis Process for the Removal of Pollutants for Coal Liquids*," co-principal investigator with C.A. Koval, **U.S. Dept. of Energy**, Pittsburgh Energy Technology Center **\$178,459**, Oct. 1988-Sept. 1990.
13. "*Removal of Organic Compounds from Exhausted Copper Plating Baths by Photodecomposition with Titanium Dioxide Particles*" co-principal investigator with C.A. Koval, **IBM, \$25,000**, Nov. 1988-Oct. 1989.
14. "*Inorganic Catalytic Membranes for Methanol Production*", **National Science Foundation, \$30,000**, Dec. 1988-Nov. 1989.
15. "*Planning Grant to Establish a University/Industry Research Center for Thin Films Research*" co-principal investigator with W.B. Krantz, **National Science Foundation, \$25,000**, Jan 1989 to June 1990.
16. "*Effects of Reaction and Transport Mechanisms on the Performance of Facilitated Transport Membranes*" co-principal investigator with C.A. Koval, **BP America EMRA Grant, \$275,983**, June 1989 May 1993.
17. "*Protein Separations Using Magnetically Stabilized Fluidized Beds*," co-principal investigator with C.A. Koval, **Colorado Institute for Research in Biotechnology and Synergen, Inc., \$20,000**, November 1989 - June 1990.
18. "*Mechanistic Studies of the Photodecomposition of Organic Compounds at Illuminated Titanium Dioxide Particles*," co-principal investigator with C.A. Koval, **IBM, \$25,000**, January 1990 - December 1990.
19. "*Convective Liquid Crystal Membranes*," co-principal investigator with N. Clark, **National Science Foundation, \$46,683**, March 1990 - February 1991.
20. "*Separation of Olefin Isomers*," co-principal investigator with M. Rakowski-DuBois, **Center for Separations Using Thin Films, \$90,000**, January 1990 - December 1992.
21. "*Acid Gas Separations with Ion-Exchange Membranes*," co-principal investigator with C.A. Koval, **Center for Separations Using Thin Films, \$90,000**, January 1990 - December 1992.
22. "*Catalytic Membrane Reactor for Butane Dehydrogenation*," co-principal investigator with J.L. Falconer, **Center for Separations Using Thin Films, \$90,000**, January 1990 - December 1992.

23. "*Direct Methane Conversion to Methanol*," co-principal investigator with J.L. Falconer, **U.S. Department of Energy**, Morgantown Energy Technology Center, **\$784,797.**, July 1990 - May, 1996.
24. "*A Reaction/Separation Process for Enhanced Methane Conversion*," co-principal investigator with J.L. Falconer, **Gas Research Institute**, **\$375,000**, October 1990 - October 1993.
25. "*Removal and Concentration of Pollutants Based on Electrochemically Modulated Complexation*," co-principal investigator with C.A. Koval, **U. S. Environmental Protection Agency**, **\$205,325**, October 1990 - September 1992.
26. "*Establishment of an Industry University Cooperative Research Center for Separations Using Thin Films*" co-principal investigator with W.B. Krantz, **National Science Foundation**, **\$300,000**, March 1991 - February 1996.
27. "*Convective Liquid Crystal Membranes*," co-principal investigator with N.A. Clark, **Center for Separations Using Thin Films**, **\$90,000**, January 1991 - December 1993.
28. "*Optimal Reactor Design and Analysis for Waste Treatment Using Photodecomposition of Environmentally-Hazardous Organic Compounds*," co-principal investigator with C.A. Koval, **IBM**, **\$221,346**, May 1991 - April 1994.
29. "*Propene/Propane Separations*," co-principal investigator with M. Rakowski-DuBois, **BP America**, **\$432,321**, November 1991 - July, 1995.
30. "*Ion Transport With Fixed Site Carrier Membranes*," co-principal investigator with C.N. Bowman, **Center for Separations Using Thin Films**, **\$105,000**, January 1993-December, 1995.
31. "*Gas Separation and Concentration Using Electrochemically Modulated Complexation*," co-principal investigator with C.A. Koval, **Center for Separations Using Thin Films**, **\$90,000**, January 1993-December, 1995.
32. "*Zeolite Membrane Fabrication and Characterization*", co-principal investigator with J.L. Falconer, **Chevron Research and Technology Co.**, **\$142,960**, February 1994-January 1996.
33. "*Use of Ion-Exchange Supports for Facilitated Transport Membranes with Enhanced Selectivity*", co-principal investigator with C.A. Koval and C.N. Bowman, **National Science Foundation and Chevron Research and Technology Co.**, **\$300,000**, January 1994-December 1995.
34. "*New Materials for Selective Absorption and/or Transport of Aromatic Hydrocarbons*", co-principal investigator with C.A. Koval, **Center for Separations Using Thin Films**, **\$105,000**, January 1994-December 1996.
35. "*Liquid Phase Separations by Pervaporation Using Zeolite Membranes*", co-principal investigator with J.L. Falconer, **Center for Separations Using Thin Films**, **\$105,000**, January, 1996-December, 1998.
36. "*Research on the Role of the Complexing Mechanism in Membrane Transport and Selectivity*", co-principal investigator with C.N. Bowman, **Center for Separations Using Thin Films**, **\$105,000**, January, 1996-December, 1998.
37. "*Development of QCM (EQCM), AFM, and SERS for Studying Absorption and Transport Phenomena in Membranes*", co-principal investigator with C.A. Koval and K. Rowlen, **Center for Separations Using Thin Films**, **\$10,000**, January 1996-December, 1996.

38. “*Development of Novel Acid/Base Facilitated Transport Membranes for Separation of Ketones, Alcohols and Thiopenes*”, co-principal investigator with C.A. Koval and T.H. Sammakia, **Center for Separations Using Thin Films, \$105,000**, January 1997-December, 1999.
39. “*Design and Development of Hydrogen Recovery Technology from Waste Gas Streams Using Zeolite Membranes*”, co-principal investigator with J.L. Falconer and T. Yamaguchi and S. Nakao, University of Tokyo, **New Energy and Industrial Technology Development Organization (NEDO) of Japanese Government, \$300,000**, April 1996-March 1999.
40. “*A Photocatalytic Membrane Reactor for Sterilization of Bioreactor Process Gas*”, co-principal investigators with W. Jacoby and M. Hernandez, **Colorado Institute for Research in Biotechnology, \$17,500**, July 1997-June 1998.
41. “*Carbon Dioxide Facilitated Transport Measurements*”, **Compact Membrane Systems, \$18,000**, April 1997-September 1997.
42. “*University/Industry Cooperative Research for Separations Using Thin Films: A five Year Renewal*”, co-principal investigator with W.B. Krantz and A.R. Greenberg, **National Science Foundation, \$190,000**, April, 1996-March, 2001.
43. “*Investigation of Composite Facilitated Transport Membranes for Separations of Unsaturated Hydrocarbons*”, co-principal investigator with C.A. Koval and C.N. Bowman, **National Science Foundation, \$75,000**, Jan., 1998-Jan., 2000.
44. “*Zeolite Membrane Synthesis*”, co-principal investigator with J.L. Falconer, **Ceramem Corp., \$20,000**, Oct., 1998- March, 1999.
45. “*Zeolite Membranes for Chemically Challenging Environments*”, co-principal investigator with J.L. Falconer, **Center for Membrane Science and Applied Technology, \$105,000**, Jan., 1999-Dec., 2001.
46. “*Basic Investigation of Controlled Periodic Illumination Effects on Photocatalytic Reactions and Selectivity*”, co-principal investigator with C.A. Koval, **National Science Foundation, \$80,000**, May, 1999-April, 2000.
47. “*Zeolite Membranes for O₂/N₂ Separations*”, co-principal investigator with J.L. Falconer, **Ceramem Corp., \$200,000**, Aug. 1999-July, 2001.
48. “*Transient Studies of Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **National Science Foundation, \$240,000**, Aug. 1999-July, 2002.
49. “*Separation of 1,3 Propane Diol from Glycerol and Glucose Using Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **DuPont Corp., \$89,256**, Sept., 1999-Aug. 2000.
50. “*Novel Electrochemical Methods for Carbon Dioxide Recovery and Utilization*”, co-principal investigator with C.A. Koval, **National Renewable Energy Laboratories, \$62, 379**, Jan. 2000-Dec. 2000.
51. “*CO₂ Separation Using Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **U.S. Department of Energy, UCR Program, \$200,000**, July 1998-June, 2001.
52. “*New Methods for Carbon Dioxide Separation and Recovery*”, co-principal investigator with Mary Rakowski-DuBois, **National Science Foundation, \$374,998**, October 2001-September 2004.

53. “*CU-UC Membrane Applied Science and Technology [MAST] Center: A Multi-University I/U CRC*”, co-principal investigator with Alan Greenberg, **National Science Foundation, \$400,000**, September, 2001-August, 2006.
54. “*Comparison of Pervaporation vs. Air Stripping*”, co-principal investigator with David Clough, **MAST Center, \$105,000.**, January, 2002-December, 2004.
55. “*Separations Using Ionic Liquids*”, co-principal investigator with Carl Koval, **MAST Center, \$105,000.**, January, 2002-December, 2004.
56. “*Zeolite Membranes for Waste Minimization in Chemically Challenging Environments*”, co-principal investigator with John Falconer, **Colorado Commission on Higher Education, \$50,124.**, January, 2002-December, 2002.
57. “*Fundamental Study of Organics Reaction/Separation Using Zeolite Membranes*”, **ACS Petroleum Research Fund, \$80,000**, July, 2002-Aug.,2004.
58. “*CO₂/CH₄ Separation with Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **Shell Global Solutions, \$201,872**, Dec. 2002-Nov. 2004.
59. “*Highly Selective H₂ Separation Zeolite Membranes for Coal Gasification Membrane Reactor Applications*”, co-principal investigator with J.L. Falconer, **DOE University Coal Research Program, \$200,000**, Oct. 2002-Sept. 2005.
60. “*Generation of Mechanical Motion Using Active Transport*”, principal investigator for multi-PI grant, **DARPA, \$1,268,833**, April 2003-March 2005.
61. “*Separations of Hydrocarbons with Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **Sandia National Laboratories, \$168,000**, Sept. 2003-Feb. 2005.
62. “*MAST Center Participation in EU Membrane Network*”, **National Science Foundation, \$400,000**, Aug. 2004-July, 2008.
63. “*CO₂/CH₄ Separation with Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **Shell Global Solutions, \$500,507**, March, 2005-Feb. 2007.
64. “*Transient Measurements of Multi-component Permeation in Zeolites*”, co-principal investigator with J.L. Falconer, **National Science Foundation, \$516,663**, Nov. 2003-October 2006.
65. “*Transport of Molecular Mixtures in Zeolite Membranes and Related Microporous Materials: A Combined Theoretical and Experimental Study*”, co-principal investigator with David Scholl and J.L. Falconer, **NSF, \$108,138**, June 2004-May 2007.
66. “*Morphing at Large Stress and Strain Through Electrochemical Actuation and Tailored Structural Design*”, co-principal investigator with Kurt Maute, Martin Dunn and Carl Koval, **Rockwell Scientific Company LLC, \$405,787**, December 2004-May 2006.
67. “*University/Industry Cooperative Membrane Research*”, principal investigator, **Colorado Institute of Technology, \$150,000**, September 2004-August 2005.
68. “*Surface Modification of Nanoporous Zeolite Pervaporation Membranes for Enhanced Biomass Product Recovery*”, co-principal investigator with J.L. Falconer, **ITN Energy Systems, \$30,000**, May 2004-Nov. 2004.
69. “*Low Power Electrochemical Pumps for Manipulation of Biological Fluids*”, co-principal investigator with C.A. Koval, **University of Colorado Technology Transfer Office, \$25,000**, Jan. 2006-May, 2006.

70. “*Reverse Osmosis in Non-Aqueous Systems*”, co-principal investigator with J.L. Falconer, **MAST Center, \$120,000**, Nov. 2005-Oct. 2008.
71. “*CO₂/CH₄ Separation with Zeolite Membranes*”, co-principal investigator with J.L. Falconer, **Shell Global Solutions, \$501,507**, March, 2005-Feb. 2007.
72. “*Novel Nanocomposite Structures as Active and Passive Barrier Materials*”, co-principal investigator with D.L. Gin, **Department of Defense, ARO, \$578,000**, March, 2007-March, 2012.
73. “*Ionic Liquid-Nanoparticle Composite Materials and Novel Air Filtration Media*”, co-principal investigator with D.L. Gin, **Defense Threat Reduction Agency, \$1,597,143**, March, 2008-March, 2012.
74. “*Modified Zeolite A Membranes for Hydrogen Selective Separations*”, co-principal investigator with J.L. Falconer, **Shell Global Solutions, \$130,266**, June, 2007-May, 2008.
75. “*Alcohol/water separations using IL-based polymer membranes*”, co-PI with Douglas Gin and Carl Koval, **Colorado Center for Biofuels and Biotechnology, \$50,000**, Jan. 2008-Dec. 2008.
76. “*Thermogravimetric Analyzer with Mass Spectrometer for Analysis of Nanocomposite Materials for Air Filtration Applications*”, **DURIP, \$150, 000**.
77. “*Achieving a 10,000 GPU Permeance for Post-Combustion Carbon Capture with Gelled Ionic Liquid-Based Membranes*”, co-PI with Douglas Gin, **DOE ARPA-E, \$3,774,805**, July 1, 2010-June 30, 2013.