Vita

Richard D. Noble

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E-Mail Address: nobler@colorado.edu
Title: Alfred T. and Betty E. Look Professor of Chemical Engineering
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	7/17 - present	Research Professor
	9/90 - 6/17	Professor
	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, (1980), (1981)
Halliburton Education Foundation Award of Excellence: Outstanding Faculty Member, Engineering College, University of Wyoming, (1980)
American Society for Engineering Education (ASEE) Zone IV Campus Activity Coordinator Award (1980)
ASEE Dow Outstanding Young Faculty Award, Rocky Mountain Section (1981)
National Bureau of Standards Outstanding Performance Award (1983)
National Bureau of Standards Sustained Superior Performance Award (1984)
ASEE AT&T Foundation Award, Rocky Mountain Section, (1985)
National Bureau of Standards Sustained Superior Performance Award (1985)
National Bureau of Standards Sustained Superior Performance Award (1987)
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)
University of Colorado Bank One Colorado Corporation 1994-95 Faculty Community Service Award
College of Engineering Outstanding Research Award (1995)
Outstanding Undergraduate Professor Award, Chemical Engineering Dept. (1995)
University of Colorado Faculty Council Award for Excellence (1995)
Japan Industrial Technology Association Foreign Researcher Fellowship (1996)
Max S. Peters Faculty Service Award, College of Engineering (1998)
Boulder Faculty Assembly Excellence in Service Award (1999)
Outstanding Undergraduate Professor Award, Chemical Engineering Dept. (1999)
Boulder Faculty Assembly Excellence in Research Award (2001)
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 Excellence in Industrial Gas Technology Award (2010)
ASEE Chemical Engineering Chemstations Lectureship Award (2011)

AIChE Separations Division Clarence G. Gerhold Award (2011)
National Society of Professional Engineers/Professional Engineers in Higher Education/Sustaining University Program Engineering Education Excellence Award (2013)
Dean's Performance Award for Research (2013)
IChemE Innovator of the Year (2013)
ACS National Award in Separation Science and Technology (2015)
Stevens Distinguished Alumni Award-Engineering (2017)
NAMS Fellow (2018)

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
Current Opinions in Chemical Engineering, Editorial Board 2011-
AIChE Journal Consulting Editorial Board 2012-
COIL-6 International Advisory Board 2015
Frontiers in Carbon Capture, Storage, and Utilization journal, Review Editorial Board, 2014- present
North American Membrane Society (NAMS), Board of Directors, 2018-2020

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. Ayral, 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.

14. Crespo, J. and Noble, R.D., "Ionic Liquid Membrane Technology", Chap. In Ionic Liquids Further UnCOILed", N.V. Plechkova and K.R. Seddon, editors, Wiley, (2014).

Patents

1. Noble, R.D; Koval, C.A.; Nixon, L.; Slaff, G.F., "*Stationary Magnetically Stabilized Fluidized Bed for Protein Separation andPurification*," U.S. Patent No. 5,084,169, Jan. 28, 1992.
2. Noble, R.D.; Koval, C.A.; Nixon, L.; 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.; 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.; 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.; 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.; Koval, C.A., "*Enhancing Performance of Perflourinated Ionomer Membranes via Dopant Incorporation,*" U.S. Patent No. 5,417,832, May 23, 1995.
9. Jia, M-D; Noble, R.D.; Falconer, J.L., "*Ceramic-Zeolite Composite Membranes and Use for Separation of Vapor/Gas Mixtures,*" U.S. Patent No. 5,464,798, November 7, 1995.
10. Sczechowski, J.G.; Koval, C.A.; 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.

11.& 12. Noble, R.D.; 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.

13. Thoen, P.; Koval, C.A.; 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.

14.& 15. Falconer, J.L.; George, S.M.; Ott, A.W.; Klaus, J.W.; Noble, R.D.; 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. Vu, T.A.; Noble, R.D.; 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.; Falconer, J.L.; Noble, R.D., *"High-Selectivity Supported SAPO Membranes,"* U.S. patent 7,316,727, January 8, 2008.
19. Gin, D.; Zhou, M.; Noble, R.D., *"Lyotropic Liquid Crystal Nanofiltration Membranes,"* U.S. Patent No. 7,604,129, October 20, 2009.

20. Li, S.; Arvidson, S.; Falconer, J.L; Noble, R.D.; "*Membranes for Highly Selective Separations,*" Eurasian Patent No. 011728, August 28, 2009.
21. Li, S.; Falconer, J.L; Noble, R.D.; "*High Selectivity Supported SAPO Membranes,*" Singapore Patent 200606129-5, February 27, 2009.
22. Li, S.; Arvidson, S.; Falconer, J.L; Noble, R.D.; "*Membranes for Highly Selective Separations,*" U.S. Patent 7,828,875, November 9, 2010.
23. Koval, C.A.; Evans, C.E.; Noble, R.D.; Norman, M.A., "*Electrochemical High Pressure Pump,*" U.S. Patent 7,718,047, May 18, 2010.
24. Gin, D.; Bara, J.; Noble, R.D.; 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 No. 7,931,824, April 26, 2011.
25. Li, S.; Falconer, J.L; Noble, R.D.; "*Membranes for Highly Selective Separations,*" U.S. Patent 8,067,327 B2, November 29, 2011.
26. Evans, C.E.; Payne, F.W.; Koval, C.A.; Noble, R.D.; Norman, M.A., "*Electrochemical Pump,*" U.S. Patent No. 8,187,441, May 29, 2012.
27. Gin, D.; Zhou, M.; Noble, R.D., "*Lyotropic Liquid Crystal Nanofiltration Membranes,*" PCT Application PCT/US03/31429, filed 10/3/03, PCT-Nationalized.
28. Noble, R.D., "*High-Selectivity Supported SAPO Membranes,*" PCT Application PCT/US2005/08590, filed 3/15/05, PCT-Nationalized.
29. Falconer, J.L.; Carreon, M.; Li, S.; Noble, R.D., "*Synthesis of Zeolites and Zeolite Membrane Using Multiple Structure Directing Agents,*" U.S. Patent 8,302,782, November 6, 2012.
30. Falconer, J.L.; Li, S.; Noble, R.D.; Yu, M., "*Reversible Hydrogen Storage using Zeolite Layers,*" U.S. Patent Application, filed 3/1/07; Provisional re-filed.
31. Falconer, J.L.; Li, S.; Noble, R.D.; Yu, M., "*A Controllable Nanometer Sized Valve,*" U.S. Patent Application, filed 3/1/07.
32. Wyse, C.L.; Torres, R.; Millward, A.R.; Noble, R.D.; Bara, J.; Gin, D., "*Fluid Storage and Purification Method and System,*" U.S. Patent Application 12/041,574, filed April 10, 2008.
33-39. Li, S.; Falconer, J.L.; Noble, R.D., "*High Flux and Selectivity SAPO-34 Membranes for CO_2/CH_4 Separations,*" European Patent Office Patent Application, filed 5/9/07, Pending; Gulf Cooperation Council Patent Application, filed 5/15/07, Pending-under review; PCT Application PCT/US2007/068542, filed 5/9/07, PCT-Nationalized; Eurasia Patent Application, filed 5/9/07, Pending-under review; Canada Patent Application, filed 10/30/08, Pending; Malaysia Patent Application, filed 10/23/08, Pending-under review; Indonesia Patent Application, filed 10/28/08, Pending-prior to examination; Australia Patent Application, filed 11/20/08, Granted-Foreign;
40. Noble, R.D., "*Valving and Storage Using Molecular Sieve Membranes,*" PCT Application PCT/US2008/055513, filed 2/29/08.
41. Camper, D.; Bara, J.; Gin, D.L.; Noble, R.D., "*Compositions and Methods for Removing Acid Gases,*" U.S. Patent Application, filed 5/21/08.

42. Noble, R.D., "*Heteroaryl Salts and Methods for Producing and Using the Same*," PCT Application PCT/US2008/086434, filed 12/11/08, PCT-Nationalized.
43. Noble, R.D., "*Ionic Liquids and Methods for Using the Same,*" PCT Application PCT/US2009/044900, PCT-Nationalized, filed 5/12/09, PCT-Nationalized.
44-46. Noble, R.D., "*Membranes for Highly Selective Separations,*" Algeria Patent 5047, 20/25/09; PCT Application PCT/US2005/27530, filed 8/1/05, PCT-Nationalized; Vietnam Patent Application, filed 3/5/07.
47-49. Carreon, M.; Diaz, Z.; Falconer, J.L.; Funke, H.; Li, S.; Murray, B.D.; Noble, R.D.; Williams, P.J., "*Method of Making a High-Performance Supported Gas Separation Molecular Sieve Membrane Using a Shortened Crystallization Time,*"US Patent 8,685,143 issued April 1, 2014; Eurasia Patent Application, filed 5/19/09, Pending; Brazil Patent Application, filed 11/11/10, Pending.
50. Bara, J.; Carlisle, T.K.; Hatakeyama, E.; Gin, D.L.; Noble, R.D.; Kerr, R.; LaFrate, A.L., "*Imidazolium-based Room-temperature Ionic Liquids, Polymers, Monomers, and Membranes Incorporating Same,*" PCT Application PCT/US2010/043124, filed 7/23/10, PCT-Nationalized.
51-54. Carreon, M.; Diaz, Z.; Falconer, J.L.; Funke, H.; Li, S.; Murray, B.D.; Noble, R.D.; Williams, P.J., "*Method of Making a High-Performance Supported Gas Separtion Molecular Sieve Membrane Using a Shortened Crystallization Time,*" Australia Patent Application, filed 10/8/10, Pending-Published; Malaysia Patent Application, filed 10/14/10, Pending; Indonesia Patent Application, filed 11/11/10, Pending-Published; European Patent Office Patent Application,filed 12/14/10, Pending.
55. Falconer, J.L.; Zhang, Y.; Noble, R.D.; Tokay, B.; Avila, A., "*High-Flux SAPO-34 Membranes for CO_2/CH_4 Separations,*" Gulf Cooperation Council Patent Application, filed 12/11/10, Pending.
56. Zhang, Y.; Noble, R.D.; Jin, Y.; Vos, B., "*Organic Porous Materials Comprising Shape-Persistent Three-Dimensional Molecular Cage Building Blocks,*" US Patent 8,993,806 issued March 31, 2015.
57. Falconer, J.L.; Zhang, Y.; Noble, R.D.; Tokay, B.; Avila, A., "*High Flux SAPO-34 Membranes for CO_2/CH_4 Separation and Template Removal Method,*" PCT Application PCT/US2011/034292, filed 4/28/11, U.S Patent 8,679,227, March 25, 2014.
58-59. Li, S.; Falconer, J.L; Noble, R.D.; "*High Selectivity Supported Membranes,"* Indonesia Application W00200602528, filed 9/12/06; Eurasia Application 20064713, filed 3/15/05.
60-62. Li, S.; Falconer, J.L; Noble, R.D., "*High Flux and Selectivity SAPO-34 Membranes for CO_2/CH_4 Separations,*" U.S. Provisional Patent Application 60/800,343 , filed 5/15/06; Patent Application 11/746,191, filed 5/9/07; PCT Application PCT/US07/68542, filed 5/9/07.
63. Li, S.; Falconer, J.L; Noble, R.D., "*Membranes for Highly Selective Separations,*" PCT Application PCT/US2005/27530, filed 8/1/05.
64. Yu, M.; Li, S.; Falconer, J.L.; Noble, R.D., "*Valving and Storage Using Molecular Sieve Membranes,*" US Patent Application, Serial Number 12/529,236, filed August 31, 2009.

65. Falconer, J.L.; Zhang, Y.; Avila, A.; Noble, R.D., "*Blocking Defects in Molecular Sieve Membranes with Cyclodextrin,*" U.S. Provisional Patent Application, November, 2009; October 2010 Pending;.
66. Zhang, Y.; Avila, A.; Falconer, J.L.; Noble, R.D., "*High Flux SAPO-34 Membranes for CO_2/CH_4 Separations,*" US Provisional Patent Application No. 61/285,703, December, 2009.
67. Yu, M.; Zhang, W.; Falconer, J.L.; Noble, R.D., "*High Efficiency Dye-sensitized Solar Cell with Layered Structures,*" US Patent Application, submitted May, 2011, Pending – Prior to Examination.
68. Tokay, B.; Zhang, Y.; Falconer, J.L.; Noble, R.D., "*High flux SAPO-34 membranes for CO_2/CH_4 Separation Prepared by New Template Removal Method,*" U.S. Patent Application, submitted April 2011.
69. Carreon, M.; Diaz, Z.; Falconer, J.L.; Funke, H.H.; Li, S.; Murray, B.D.; Noble, R.D.; Williams, P.J., "*Method of Making a High-Performance Supported Gas Separation Molecular Sieve Membrane Using a Shortened Crystallization Time,*" U.S. Patent Application filed October 7, 2010. Serial Number 12/936,795.
70-72. Bara, J.; Hatakeyama, E.; Gin, D.L; Lessmann, S.; Noble, R.D., "*Heteroaryl Salts and Methods for Producing and Using the Same,*" European Patent Application, submitted June 2010; Japan Patent Application, submitted June 2010; U.S. Patent Application, submitted December, 2008.
73. Bara, J.; Camper, D.; Gin, D.L.; Noble, R.D.," *Ionic Liquids and Methods for Using the Same,*" U.S. Patent Application, submitted February, 2007.
74. and 75. Bara, J.; Carlisle,T.; Hatakeyama, E.; Gin, D.L.; Noble, R.D.; Kerr, R.; LaFrate, A., "*Imidazolium-Based Room-Temperature Ionic Liquids, Polymers, Monomers, and Membranes Containing the Same,*" U.S. Patent No. 8,926,732, January 6, 2015, U.S. Patent No. 9,446,348, September 20, 2016.
76. LaFrate, A.; Bara, J.; Gin, D.L.; Noble, R.D., "*Diol-Functionalized, Imidazolium-Based Room-Temperature Ionic Liquids and Monomers,*" U.S. Patent Application, submitted July, 2009.
77. Bara, J.; Carlisle, T.; Hatakeyama, E.; Gin, D.L.; Noble, R.D.; Kerr, R., "*Cationic Polymers Based on and Interfaced with Room-Temperature Ionic Liquids and Their Use as Gas Separations and Gels,*" U.S. Patent Application, 61/228,433, filed July 24, 2009; pending 12/11/10.
78. Gin, D.L.; Carter, B.M.; Wiesenauer,B.; Hatakeyama,E.; Noble,R.D.; Barton, J.L., "*New Methods for Formulating and Preparing Nanoporous, Bicontinuous Cubic Lyotropic Liquid Crystal Polymer Membranes that Enable Facile Film Processing and Pore Size,*" Provisional U.S. Patent Application 61/510,931, filed July 22, 2011
79. Noble, R.D., "*Organic Porous Materials Comprising Shape-Persistent Three-Dimensional Molecular Cage Building Blocks*," U.S. Patent Application, submitted March 19, 2010; Pending.
80.Gin, D. L.; Carlisle, T. K.; Noble, R. D.; Nicodemus, G. D.; McDanel, W., Cowan, M., "*Composites Comprising Novel RTIL-based Polymers, and Methods of Making and Using Same*," U.S. Patent9,687,840, issued July 27, 2017.
81.Gin, D. L.; Carter, B. M.; Wiesenauer, B. R.; Hatakeyama, E. S.; Noble, R. D.; Barton, J. L., "*Method and Membrane for Nanoporous, Bicontinuous Cubic Lyotropic*

Liquid Crystal Polymer Membranes that Enable Facile Film Processing and Pore Size Control," PCT Patent Application PCT/US2012/047779, filed July 22, 2012.
82. Falconer, J.L.; Funke, H.; Ping, E.W.; Zhou, M.; Noble, R.D., *"Seeded-gel Synthesis of High Flux and High Selectivity SAPO-34 Membranes for CO_2/CH_4 Separtions,"* Provisonal U.S. Application 61/585,521, filed January 11, 2012.
83. Koval, C.A.; Evans, C.E.; Noble, R.D. and Norman, M.A., "*Electrochemical High Pressure Pum*p", US Patent 8,343,324, issued January 1, 2013.
84. Bailey, T.S.; Guo, C.; Lewis, J.T.; Fischenich, K.; Donahue, T.H.; Wijayasekara, D.; Cowan, M.G.; Gin, D.L. and Noble, R.D., "Block Copolymer Hydrogel Used in Membrane for Battery Separator, Comprises Glass Formed from Dry Blend Comprising Polystyrene-Polyethylene Oxide diblock Copolymer and Polystyrene Polyethylene Oxide Polystryrene Triblock Copolymer", Patenet No. WO2017096367-A1.
85. Hill, M.R.; Lau, C.H.; Konstas, K.D.; Nguyen, P.T.; Gin, D.L. and Noble, R.D., "Mixed Matrix Polymer Compositions", US Patent No.9815032, issued November 14, 2017.
86. Gin, D.L.; Noble, R.D.; Dischinger, S.M. and Carter, B.M., "Nanoporous lyotropic liquid crystal polymer membrane used for increasing concentration of uncharged solute in first solution, comprises cationic LLC polymer having pore in which anionic counterion is located, and anionic counterion" US Patent No. US2018208728-A1.
87. Gin, D.L.; Dunn, C.A.; Singh, Z. and Noble, R.D., "Composition used for separating gas mixture, comprises porous solid, non-polymerizable room-temperature ionic liquid and polymer comprising backbone and side chains comprising ionic liquid, functionalized with self cross-linking group" Patent No. WO2019232074-A1, Publication Date Dec. 5, 2019.

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 Pyrolsis: 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).

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350. Dwulet, G.E.; Dischinger, S.M.; McGrath, M.J.; Basalla, A.; Malecha, J.; Noble, R.D.; and Gin, D.L., "*Breathable, Polydopamine-coated Nanoporous Membranes that Selectively Reject Nerve and Blister Agent Simulant Vapors*", **Industrial and Engineering Chemistry Research, 58(47),** 21890-21893 (2019).
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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).
15. "John Falconer of the University of Colorado Boulder", **Chemical Engineering Education**, 74-80, Spring 2013.

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, **BPAmerica** 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, **BPAmerica**, **$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 O_2/N_2 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. "*CO_2 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. "*CO_2/CH_4 Separation with Zeolite Membranes*", co-principal investigator with J.L. Falconer, **Shell Global Solutions, $201,872**, Dec. 2002-Nov. 2004.
59. "*Highly SelectiveH_2 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. "*CO_2/CH_4 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. "*CO_2/CH_4 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.
78. "*Study and Development of a New Type of Water Nanofiltration Membrane with an Ordered, Sub-one-nanometer Size Pore System*"; co-PI with Douglas L. Gin, **National Science Foundation (CBET Division (Chem. & Biol. Separations Program)); $280,000**; July 1, 2j009-May 31, 2013.
79. "*A Multi-Site University/Industry Cooperative Research Center for Membrane Applied Science and Technology*", **National Science Foundation**; co-PI with Alan. R. Greenberg, **$400,000** August 1, 2010-July 31, 2015 (Funding for administrative support of the MAST Center.
80. "*High-Efficiency, Dye-Sensitized Solar Cells*"; **National Science Foundation**; **$300,000**; August 1, 2010-July 31, 3013, 4 P.I. (J. L. Falconer (PI), W. Zhang, M. Yu, R. D. Noble).
81. "*Highly Selective Separation of CO_2/CH_4 Mixtures in SAPO Membranes*", **Shell Global Solutions, $770,000**; 2 investigators (R. D. Noble (PI), J. L. Falconer).
82. "*Study of Functionalized Room-temperature Ionic Liquid Membrane Materials for Use in Ethylene/Ethane Gas Separations*", **Membrane Applied Science and Technology Center**; **$127,500** September, 2011-August, 2014, 2 investigators (R. D. Noble (PI), D. L. Gin).
83. "*Novel Membranes for Recovering Water-soluble Fuels and Fuel Intermediates from Fermentation Broths*"; **Membrane Applied Science and Technology Center; $150,000**, January, 2013-December, 2016, 2 investigators (R. D. Noble (PI), and D. L. Gin) .
84. "*MRI Acquisition: An integrated platform for combined multi-scale mechanical and chemical analysis to inform functional materials design*",**National Science Foundation, $434,112 with a matching of $186,050**. There are several principal investigators on this award.
85. "*Evaluation and Development of a New Type of Polymer-Based Water Desalination Membrane Containing Uniform, Molecular-Size, Ionic Pores*"; **U.S. Bureau of Reclamation (Desalination and Water Purification Research Program); $150,000**; October, 2013-September, 2014, 2 investigators (D. L. Gin (PI) and R. D. Noble.

86. "*Responsive Sequestration Coating (Phase II)*"; **Defense Threat Reduction Agency / Army Research Office (Phase 2 SBIR subcontract with TDA Research, Inc.); $280,000**; May, 2014-April, 2016, 4 investigators (B. J. Elliott (PI) W. A. Ellis, D. L. Gin, and R. D. Noble).
87. "*Energy Efficient Electrochemical Capture and Release of Carbon Dioxide*"; **U.S. Dept. of Energy (Advanced Research Projects Agency – Energy program); $3,625,000**; August, 2014-August, 2016, 7 investigators (D. Buttry (PI), R. D. Noble, D. L. Gin, K. Ayers, E. Stechel, C. Freisen, V. Mujica).
88. "*Development of Ionic Liquid Polymer-based Materials and Membranes for Selective CO_2/CH_4 Gas Separations*" **TOTAL SA**, November, 2015-May, 2017, PI with Douglas L. Gin, **$175,000**. May, 2017 – May, 2020**, $200,000**.
89. "*I/U CRC Membrane Science, Engineering and Technology Center: 5-year Renewal*" **National Science Foundation**, Noble, R.D., Bright, V.M.; and Greenberg, A.R.; **$500,000**, July, 2016-June, 2021.
90. "*Anion Channel Membranes*"; **U.S. Dept. of Energy (Advanced Research Projects Agency – Energy program); $3,000,000**; December, 2016-June, 2019, 4 investigators R. D. Noble, D. L. Gin, P. Liu (UCSD), J. Song (ESS Inc).
91. " *Chemical Modifications of Nanoporous Liquid Crystal Polymer Membranes to Improve Stretchability*",**Army Research Office**, D.L. Gin and R.D. Noble, **$100,000**, July, 2019 –December, 2019,
92. "*High-MVTR, Stretchable, Biomimetic Porous Polymer Membranes for Chemical/Biological (CB) Defense***", Defense Threat Reduction Agency / Army Research Office,** N. Pomerantz, D.L. Gin, R.D. Noble, M. Shirts, **$2,410,000**, 5 years, approved for funding.