American Chemical Society

National Awards Nomination Packet

ACS Award in Industrial Chemistry:2018
for: Richard Baker

Received: 10/31/2014 *Cycle Year: 3*

"In recognition of lifetime commitment, extraordinary achievements and excellence in bringing membrane science and technology from fledgling theory through product development to commercial reality."

NOMINATOR:

sara soder Email: sara.soder@mtrinc.comXXX

- Have you discussed this award nomination with the nominee? *No*

NOMINEE:

Richard Baker Email: rwbaker@mtrinc.comXXX

Membrane Techlgy & Rsrch
39630 Eureka Dr
Newark, CA 94560-4805
UNITED STATES

ACS Current Member: Yes
Years of Service: 48
Date of birth: 01/01/1941
Present Position: Principal Scientist, Membrane Technology & Research, Inc.
Industry: Industry

SAFETY PROTOCOLS:

- Does the nominee employ and require good safety protocols and practices in his/her laboratory? *Yes*

SUPPORTER 1

Hans Wijmans Email: hans.wijmans@mtrinc.comXXX

THE UNIVERSITY OF TEXAS AT AUSTIN
COCKRELL SCHOOL OF ENGINEERING

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October 27, 2014

Award Review Committee
American Chemical Society

RE: Recommendation letter for Dr. Richard W. Baker for the ACS Award in Industrial Chemistry

In the membrane separations field, Dr. Richard Baker is the most qualified nominee worldwide for this award. Using polymers to control small molecule transport is a relatively new field, and Dr. Baker literally grew up with this field over the past 50 years, making extraordinarily important contributions. Dr. Baker spent more than 40 years in industry, driving many of the most important practical breakthroughs in this field. His entrepreneurial bent is evident, having started three successful companies and enabling the development of two others. No one in this field has made so many critically important discoveries and technological advances.

Dr. Baker began his industrial career with Amicon Corporation in the late 1960s, developing the Diaflow® ultrafiltration membranes. At the time, ultrafiltration membranes were quite new, and Amicon was an early leader. Dr. Baker's work accelerated the development and availability of such membranes, which are now ubiquitous in municipal and industrial water treatment applications and in a plethora of pharmaceutical and biotechnology applications. In the early 1970s, he worked at Alza Corporation, which pioneered use of polymer membranes for controlled delivery applications. Dr. Baker helped develop the highly successful Ocusert® delivery system for glaucoma treatment. This early example of controlled delivery technology underpins the multibillion-dollar industry existing today. In 1974, Dr. Baker founded his first company, Bend Research Incorporated. Bend developed an extraordinarily strong technical and scientific reputation for innovative applications of polymer membranes. Ultimately, Pfizer acquired Bend to gain access to Bend's technology related to pharmaceutical applications.

In 1982, Dr. Baker founded his second company, Membrane Technology and Research, Incorporated (MTR), serving as President for 25 years. Initially, he focused on membranes for drug delivery and for industrial separations. The drug delivery technology was spun off in a joint venture called Pharmetrix Corporation, which was sold to an Italian industrial chemistry and pharmaceuticals company.

At MTR, Dr. Baker introduced highly innovative membrane technologies to the field. A particularly successful product has been their VaporSep® membranes that remove organic vapors from air and nitrogen. MTR installed more than 100 of these units worldwide in applications such as ethylene and propylene removal from purge bins in polyethylene and polypropylene production facilities. Cumulative VOC recovery from VaporSep units over the last 20 years is estimated to be in the range of 8-10 million tons, valued at $3-4 billion. The company is now pursuing additional new technologies in greenhouse gas mitigation (especially carbon capture) and sustainable energy processes, bringing the efficient, environmentally friendly aspects of membrane technology to an increasingly broad cross-section of industry and society.

MTR has been highly successful and has grown into one of the largest industrial membrane separations companies in the world, but this accomplishment alone does not do justice to Dr. Baker's contributions. In addition to being a pioneer in the use of polymers to control small molecule transport for pharmaceutical and industrial applications, he has for decades been a highly visible intellectual leader. His 1987 book on controlled release technology remains a cornerstone reference. His more recent book on industrial applications of membrane technology is now in its third edition and is, by far, the most important book on this subject. He has provided exemplary service to the scientific community, being a founder and past president of the International Controlled Release Society, a founder of the North American Membrane Society (NAMS), which is the primary technical outlet for membrane research in the U.S., and a journal editor for leading journals in the field. He was recognized for the innovative product development at MTR with IR 100 Awards in 1984 and 1990. He received the *Chemical Engineering Magazine* Kirkpatrick award in 1997 for vapor separation technology and the inaugural Alan S. Michaels Award for Innovation in Membrane Science and Technology in 2002, the highest award offered by NAMS. He has contributed numerous outstanding and highly cited articles to the scientific literature and has over 130 patents. A sampling of his more famous papers include a review of the solution-diffusion model (*J. Membrane Sci.*, 107, 1-21 (1995)) as well as reviews of the use of membranes for natural gas separations (*I&EC Research*, 47, 2109–2121 (2008)) and for separations in general (*I&EC Research*, 41, 1393–1411 (2002)).

In summary, no one has done more from an industrial perspective to advance the field of controlled release and membrane separations than Richard Baker. Based on his extraordinarily creative, important and bountiful contributions, he is the obvious choice for this award.

Sincerely,

Benny D. Freeman

Benny D. Freeman
Richard B. Curran Centennial Chair in Engineering
McKetta Department of Chemical Engineering, Center for Energy and Environmental Resources, and Texas Materials Institute

Richard W. Baker, Ph.D.

Richard Baker received his doctorate in physical chemistry in 1966 at Imperial College, London, where he studied under Professor R. M. Barrer, one of the pioneers of membrane science. Subsequently, he joined Amicon Corporation, Lexington, MA, and developed a series of ultrafiltration membranes now sold under the name Diaflow®. While at Alza Corporation, Palo Alto, CA from 1971 to 1974, he collaborated in the development of the Ocusert® ocular delivery system. In 1974, he co-founded Bend Research, Inc., Bend, OR, where he was the Director of Research until 1981.

In 1982, Dr. Baker left Bend Research and founded his second company, Membrane Technology and Research, Inc. (MTR), where he served as president for twenty-five years. Dr. Baker's work at MTR focused on two areas: membrane-based drug delivery systems and membranes for industrial separations. The drug delivery technology was spun off in a joint venture, Pharmetrix Corporation, with Recordati Industria Chimica e Farmaceutica S.p.A. in 1987. Dr. Baker was president of Pharmetrix until 1989 and served on the Board of Directors until 1994.

MTR has become a leading membrane research, development, engineering, and production company, concentrating on the development of membranes and membrane systems for industrially and environmentally significant separations. The company's principal membrane products are VaporSep® membrane systems to remove organic vapors from air and nitrogen. More than 100 commercial units have been installed worldwide in chemical and petrochemical plants. MTR has also developed other gas separation technologies for applications in the natural gas processing and petroleum refining industries.

In 2007, Dr. Baker stepped aside as MTR's president, but remains a member of the Board of Directors, and is leading a new development program for MTR's membrane-based biomass/biofuel ethanol separations technology.

Dr. Baker is involved in the membrane research community and frequently gives presentations and educational workshops at national and international meetings. He is a founder and past president (1981-82) of the International Controlled Release Society and also helped found the North American Membrane Society (NAMS), serving on the NAMS governing board from 1986 to 1989. He is currently on the editorial board of *The Journal of Membrane Science*; he was previously on the editorial boards of *Industrial & Engineering Chemistry Research, The Journal of Controlled Release* and *Separation and Purification Technology*, and served as editor of the NAMS quarterly newsletter for several years.

His work in membrane science has been recognized by several awards, including an IR 100 Award in 1984 for work on facilitated transport gas separation membranes and another in 1990 for the development of the MTR membrane vapor separation technology. He received the Controlled Release Society's Founders' Award in 1985. In 1997, he received the *Chemical*

Engineering Magazine Kirkpatrick award for monomer recovery in polyolefin plants. In 2002, Dr. Baker received the first Alan S. Michaels Award for Innovation in Membrane Science and Technology, presented by the North American Membrane Society.

Dr. Baker is the author of more than 100 papers and over 130 patents, all in the membrane area. His book, *Controlled Release of Biologically Active Agents* was published in 1987, and three editions of his book *Membrane Technology and Applications* were published in 2000, 2004 and 2012.

Memberships:
American Association for the Advancement of Science
American Chemical Society
European Society of Membrane Science and Technology
The Controlled Release Society: Program Chairman, 1979; President, 1981-82
North American Membrane Society: Board of Directors (1986-89)

Editorial Boards:
Journal of Membrane Science (1978-87, 1991-present); Industrial and Engineering Chemistry (2009-2012); Journal of Controlled Release (1984-1996), Separation and Purification Technology (2000-2003), Biomedical Polymers, Topics in Controlled Release Science (1985-86).

Editor:
North American Membrane Society Quarterly (1986-89)

Awards:
R&D-100 Award for Research on Oxygen Facilitated Transport Membranes, 1984
Founders' Award, Controlled Release Society, 1985
Innovation Award: San Francisco Small Business Administration District, 1986
R&D 100 Award for Membrane Vapor Recovery Systems, 1990
1997 Chemical Engineering Magazine's Kirkpatrick Award for monomer recovery in polyolefin plants.
2002 American Institute of Chemical Engineers, Separation Division Award.
2002 North American Membrane Society, Alan S. Michaels Award.

ACS Award Information:

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Cell Phone: None
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Email: Richard.Baker@mtrinc.com

Date of Birth: August 18, 1941

Richard W. Baker, Ph.D.

Dr. Baker is the author of more than 100 papers and over 130 patents, all in the membrane area; several additional patents are pending. His book, *Controlled Release of Biologically Active Agents* was published in 1987, and three editions of his book *Membrane Technology and Applications* were published in 2000, 2004 and 2012. Dr. Baker's books have garnered a few thousand citations in other published works (1123 citations in SCOPUS count; 2809 in Google Scholar). He has also contributed six articles on membranes and membrane technology to various encyclopedias of science and technology, and numerous chapters to books in specialized fields of membrane science and technology.

A list of selected publications and patents for Dr. Baker follows. The publications reflect primarily those articles cited most frequently in other publications, based on SCOPUS and Google Scholar listings; the patents were selected to reflect the span of Dr. Baker's inventions with commercially significant value.

Citation counts in parentheses at end of each reference: SC= SCOPUS; GS = Google Scholar.
Total citation counts by source for publications listed: 2,697 in SCOPUS (no count available for publication 2 below), and 4,267 in Google Scholar (including publication 2).

Selected Publications
(Citation counts in parentheses at end of each reference. SC= SCOPUS; GS = Google Scholar)

1. J.G. Wijmans and R.W. Baker, "The Solution-Diffusion Model: A Review," *J. Membr. Sci. 107*, 1-21 (1995). (872SC; 1157GS)

2. R.W. Baker and H.K. Lonsdale, "Controlled Release Mechanisms and Rates," in *Controlled Release of Biologically Active Agents*, A.C. Tanquary and R.E. Lacey, Eds., Plenum Press, New York, NY, pp 15-72 (1974). (NA in SC; 536GS)

3. R.W. Baker, "Future Directions of Membrane Gas Separation Technology," *Ind. Eng. Chem. Res. 41*, 1393-1411 (2002). (550SC; 780GS)

4. H. Strathmann, K. Kock, P. Amar, and R.W. Baker, "The Formation Mechanism of Asymmetric Membranes," *Desalination 16*, 179-203 (1975). (217SC; 401GS)

5. R. W. Baker and K. Lokhandwala, "Natural Gas Processing with Membranes: An Overview," *Ind. Eng. Chem. Res. 47(7)*, 2109-2121 (2008). (223SC; 301GS)

6. T. C. Merkel, H. Lin, X.Wei and R. W. Baker, "Power Plant Post-Combustion Carbon Dioxide Capture: An Opportunity for Membranes," *J. Membr. Sci. 359* (1-2), 126-139 (2010). (292GS)

7. K.L. Lee, R.W. Baker, and H.K. Lonsdale, "Membranes for Power Generation by Pressure-Retarded Osmosis," *J. Membr. Sci. 8(2)*, 141-171 (1981). (211SC; 276GS)

8. I. Blume, J.G. Wijmans, and R.W. Baker, "The Separation of Dissolved Organics from Water by Pervaporation," *J. Membr. Sci. 49*, 253-286 (1990). (122SC; 177GS)

9. J.G. Wijmans and R.W. Baker, "A Simple Predictive Treatment of the Permeation Process in Pervaporation," *J. Membr. Sci. 79*, 101-113 (1993). (113SC; 136GS)

10. R.W. Baker, J. G. Wijmans and Y. Huang, "Permeability, Permeance and Selectivity: A Preferred Way of Reporting Pervaporation Performance Data," *J. Membr. Sci. 348*, 346 (2010). (92 SC; 112GS)

11. R.W. Baker, J.G. Wijmans, and J.H. Kaschemekat, "The Design of Membrane Vapor-Gas Separation Systems," *J. Membr. Sci. 151*, 55-62, (1998). (71SC; 99GS)

12. R.W. Baker and B.T. Low, "Gas Separation Membrane Materials: A Perspective," *Macromolecules*, published as ACS ASAP Paper (manuscript number ma501488s), September 2014.

Selected Patents

1. J. Kaschemekat, R.W. Baker, and J.G. Wijmans, "Process for Removing Condensable Components from Gas Streams," U.S. Patent 5,205,843 (April 27, 1993).

2. J. Kaschemekat, R.W. Baker and J.G. Wijmans, "Processing for Removing Condensable Components from gas Streams," U.S. Patent 5,374,300 (December 20, 1994).

3. R.W. Baker, I. Pinnau, Z. He, A.R. Da Costa, K.D. Amo, and R. Daniels, "Hydrogen Gas Separation Using Organic-Vapor-Resistant Membranes," U.S. Patent 6,544,316 (April 8, 2003).
4. R.W. Baker, I. Pinnau, Z. He, K.D. Amo, A. R. Da Costa, R. Daniels, " Carbon Dioxide Gas Separation Using Organic-Vapor-Resistant Membranes," U.S. Patent 6,572,680 (June 3, 2003).

5. R.W. Baker, J.G. Wijmans, T.C. Merkel, H. Lin, R. Daniels, and S. Thompson, "Gas separation process using membranes with permeate sweep to remove CO_2 from combustion gases," International Publication No. WO2009/139835 (November 19, 2009) and U.S. Patent 7,964,020 (June 21, 2011).

6. Y. Huang, J. Ly, T. Aldajani, and R.W. Baker, "Liquid- and vapor-phase dehydration of organic/water solutions," U.S. Patent 8,002,874 (August 23, 2011).

7. L. M. Vane, F.R. Alvarez, Y. Huang**,** and R.W. Baker, "Membrane-augmented distillation with compression to separate solvents from water," U.S. Patent 8,114,255 (February 14, 2012).

8. J.G. Wijmans, R.W. Baker, T.C. Merkel, "Process for separating carbon dioxide from flue gas using sweep-based membrane and absorption steps," U.S. Patent 8,246,718 (August 21, 2012).

Book Citations (Citation counts)

R.W. Baker, *Controlled Release of Biologically Active Agents*, John Wiley & Sons, New York (1987). (528GS)

R.W. Baker, *Membrane Technology and Applications*, McGraw-Hill, New York, NY (2000). (2281GS)

R.W. Baker, *Membrane Technology and Applications*, 2nd edition, John Wiley & Sons, Ltd, Chichester, UK (2004).

R.W. Baker, *Membrane Technology and Applications*, 3rd edition, John Wiley & Sons, Ltd, Chichester, UK (2012). (1123Scopus)

MTR Membrane Technology & Research

October 30, 2014

Award Review Committee
American Chemical Society

RE: Letter Supporting the Recommendation of Dr. Richard W. Baker for the ACS Award in Industrial Chemistry

It is my great pleasure to write this letter in support of the recommendation of Dr. Richard W. Baker for the ACS Award in Industrial Chemistry. I have worked closely with Richard Baker ever since 1984, when I joined Membrane Technology and Research (MTR), Inc., the company founded by Richard Baker in 1982. I am still at MTR, having succeeded Dr. Baker as company President in 2007.

Initially educated as a physical chemist, Richard Baker has demonstrated himself to be exceptionally talented in the fields of chemistry, chemical engineering and business. This unusual combination of skills, coupled with extraordinary vision and determination, has allowed him to build MTR into a company that has had unparalleled impact on the industrialization of membrane gas separation technology, and that now develops, manufactures and sells separation solutions across the spectrum of the petrochemical, natural gas and refinery industries.

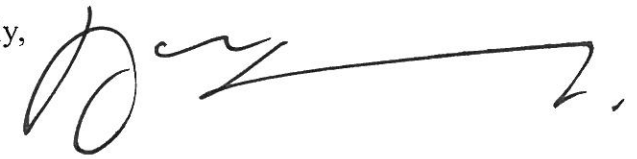
The foundation of MTR is its research and development effort, from which all products have emanated. Dr. Baker has been at the heart of this R&D effort from the beginning, and, as Principal Scientist, continues to be a key player. His ongoing emphasis on the importance of research has enabled MTR to be recognized by many as the most innovative company in membrane gas and vapor separations.

MTR currently employs almost 100 people, most of whom have chemistry and engineering degrees. The MTR membrane-based products offer our customers solutions for separation problems that are more energy-efficient, more materials-efficient, and therefore more cost-effective, than other separation technologies. Across many industries, separations require a significant portion of total capital investment and often are responsible for the majority of the energy consumption. Efficient separations, therefore, are of great importance to these industries, including the chemical process industries.

In most cases, efficient separation processes result in reduced emissions of chemicals, which is an important benefit to society at large. An example is the MTR VaporSep® process used in over 100 polyolefin plants worldwide, for the recovery of feedstock chemicals. The 2014 combined recovery capacity exceeds one million ton/year of propylene, ethylene and butane. Another example involving societal benefit is the significant program under way at MTR, supported by the Department of Energy, to apply membranes to the capture of carbon dioxide in power plants. This application once more demonstrates that innovation requires excellence in both chemistry (improved membranes) and engineering (improved processes), which is what typifies Richard Baker.

In conclusion, the career of Dr. Richard Baker exemplifies excellence in Industrial Chemistry and he is most deserving of the ACS Award.

Sincerely,



Dr. Hans Wijmans
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