Membrane Technology for Water Treatment in Membrane Center in Kobe University

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Abstract

We have established the Center for Membrane and Film Technology (MAFTech Center) in 2007, which is the first and only-one university-driven membrane research center in Japan. Currently we are collaborating with more than 70 industrial companies, as well as partnering with 14 academic membrane research centers overseas. In 2015, the integrated membrane research building (6000m^2) finished its construction and started its operation. It is the most diverse research unit integrating all aspects from basic to applied research. Researches based on the many different backgrounds are intensively and synergistically carried out in this facility. Our goal is the contribution to achieve sustainable society in future via membrane and membrane process innovations.

In my presentation, I will introduce our researches about FO membrane technology in our Membrane Center. We developed two key technologies for FO membrane process; a draw solution (DS) and an innovative FO membrane specified for forward osmosis. Using these technologies we established energy-effective FO membrane process.

We succeeded in the development of a high performance DS that is composed of temperature-responsive ionic liquid (IL). The IL-based DS showed high osmotic pressure and low viscosity, and is separable from water at around 70 C by phase separation. These characteristics are very suitable for the use in the FO process in which DS should be regenerated by using low-grade waste heat.

An innovative water channel-incorporated FO membrane was also developed. The cyclic peptide-based water channel, designed by MD simulation, showed high water permeability and high salt rejection. The peptide water channel was constructed in the lipid bilayer of liposomes and incorporated into polyamide matrix of a composite membrane fabricated onto a porous support membrane.

Using DS and FO membrane developed in our laboratory, a lab scale desalination test plant was constructed and successfully operated to continuously produce fresh water from artificial sea water. The power input and cost for desalination by the FO process were calculated.

In addition to FO membrane research, I introduce the researches on membrane fouling, oil/water separation and nano-sheet membrane.

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BIRTH of DATE 1960, April 11th

EDUCATIONAL QUALIFICATIONS

B.Eng.	(1983) Kyoto University
M.Eng.	(1985) Kyoto University
Dr.Eng.	(1990) Kyoto University

PROFESSIONAL EXPERIENCE

1985 - 1994	Assistant Professor, Kyoto Institute of Technology
1994 - 1998	Lecturer, Okayama University
1996 - 1997	Visiting Researcher, The University of Texas at Austin
1998 - 1999	Associate Professor, Okayama University
1999 - 2004	Associate Professor, Kyoto Institute of Technology.
2004 - Present	Professor, Kobe University
2007 - Present	Director of Center for Membrane and Film Technology
Present	President of Aseanian Membrane Society
	Vice President of Membrane Society of Japan

AWARDS

1992	Award of The Society of Chemical Engineers of Japan
1997	Award of The Membrane Society of Japan
2002	Outstanding Paper Award of Society of Chemical Engineers of Japan
2004	Outstanding Paper Award of Society of Chemical Engineers of Japan
2009	Research Award of Society of Chemical Engineers of Japan
2012	Lifetime Achievement Award of Society of Chemical Engineers of Japan
2013	Iue Culture Award

PUBLICATIONS

320+ referred publications, 6 books and 69 patents

Sum of the Times Cited: 6128
H-index: 44

Selected papers

1) M. Shibuya, M. Yasukawa, S. Goda, H. Sakurai, T. Takahashi, M. Higa, H. Matsuyama, Experimental and Theoretical Study of a Forward Osmosis Hollow Fiber Membrane Module with a Cross-wound Configuration, Journal of Membrane Science, 504, 10-19 (2016)

2) Z. Zhou, S. Rajabzadeh, A. R. Shaikh, Y. Kakihana, T. Ishigami, R. Sano, H. Matsuyama, Preparation and Characterization of Antifouling Poly (vinyl chloride-co-poly (ethylene glycol) methyl ether methacrylate) Membranes, Journal of Membrane Science, 498, 414–422 (2016)

3) F. Moghadam, E. Kamio, A. Yoshizumi and H. Matsuyama, Amino Acid Ionic Liquid-based Tough Ion Gel Membrane for CO2 Capture, Chemical Communications, 51, 13658 - 13661 (2015)

4) M. Yasukawa, S. Mishima, M. Shibuya, D. Saeki, T. Takahashi, T. Miyoshi and H. Matsuyama, Preparation of a Forward Osmosis Membrane using a Highly Porous Polyketone Microfiltration Membrane as a Novel Support, Journal of Membrane Science, 487, 51-59 (2015)

5) Y. Mino, T. Ishigami, Y. Kagawa, and H. Matsuyama, Three-Dimensional Phase-Field Simulations of Membrane Porous Structure Formation by Thermally Induced Phase Separation in Polymer Solutions, Journal of Membrane Science, 483, 104–111 (2015)

6) A.R. Shaikh, E. Kamio, H. Takaba, H. Matsuyama, Effects of Water Concentration on the Free Volume of Amino Acid Ionic Liquids Investigated by Molecular Dynamics Simulations, Journal of Physical Chemistry B, 119 (1), 263–273 (2015)

7) T. Ishigami, Y. Kasuya, S. Rajabzadeh, Y. Ohmukai, Y. Kakihana, H. Matsuyama, Effect of solidification rate of polymer solution on the die-swell during hollow fiber spinning by non-solvent induced phase separation, Journal of Membrane Science., 472 194–201 (2014)

8) Y. Kagawa, T. Ishigami, K. Hayashi, H. Fuse, Y. Mino and H. Matsuyama, Permeation of concentrated oil-in-water emulsions through a membrane pore: Numerical simulation using a coupled level set and the volume-of-fluid method, Soft Matter, 10 (40), 7985-7992 (2014)

9) R. Takagi, M. Vaselbehagh, H. Matsuyama, Theoretical study of the permselectivity of an anion exchange membrane in electrodialysis, Journal of Membrane Science., 470, 486–493 (2014)

10) S. Kasahara, E. Kamio, A. Yoshizumi, H. Matsuyama, Polymeric ion-gels containing an amino acid ionic liquid for facilitated CO2 transport media. Chemical Communications, 50 (23), 2996 - 2999 (2014)

RECENT RESEARCH PROJECTS

2010-2013	Mega-ton Water System	Frontier Research and Development Supporting Program by NEDO, Japan	~52M YEN
2011-2016	Hyogo Environment/Energy Innovation Cluster	Regional Innovation Strategic Program by MEXT, Japan	~389M YEN
2011-2014	Fabrication of CO_2 Selective Transmission Ion-gel Membrane by using Reactive Ion Liquid	Frontier Low-Carbon Technology R&D Program by JST, Japan	~21M YEN

2011-2014	Towards Zero Energy Consuming Waste Water Concentration via Voluntary Water Permeable Membrane	Basic Research Grant B type (KAKENHI) by MEXT, Japan	~18M YEN
2011-2014	Nitrogen Removal from Coking Wastewater via High Performing Microorganism imported Oxygen-free filtration and Membrane Bioreactor	Strategic International Collaborative Program by JST, Japan	~14M YEN
2014-2015	Low Cost and Energy Consumption CO_2 Separation via High Performing CO_2 Selective Transmission Membrane	Frontier Research and Development Supporting Program by NEDO, Japan	~16M YEN
2015-2018	Towards Zero Energy Consuming Waste Water Concentration via Voluntary Water Permeable Membrane	Basic Research Grant A type (KAKENHI) by MEXT, Japan	~38M YEN
2016-2017	Development of Innovative Low-Energy Water Treatment Technology Using Forward Osmosis Membrane	Frontier Research and Development Supporting Program by NEDO, Japan	~90M YEN

KEYNOTE AND INVITED TALKS

2017

- Invited talk at Hong Kong University, Korea (December)
- Keynote presentation at the 10th International Desalination Workshop (IDW2017), Korea (November)
- Keynote presentation at 2017 International Membrane Conference in Taiwan (IMCT2017), Taiwan (May)
- Keynote presentation at Engineering With Membranes 2017, Singapore (April)

2016

- Keynote presentation at the 9th International Membrane Science and Technology Conference (IMSTEC), Australia (December)
- Keynote presentation at the International Forward Osmosis Summit (IFOS 2016), Australia (December
- Invited talk at University of Technology Sydney, Australia (December)
- Invited talk at Victoria University, Australia (December)
- Invited talk at Seminar Tantangan Global Pengelolaan Perusahaan Daerah Air Minum, Indonesia (September)
- Invited talk at Zhejiang University, China (September)
- Invited talk at Zhejiang University of Technology, China (September)
- Invited talk at Nanjing Technology University, China (September)
- Invited talk at Changzhou University, China (September)
- Keynote presentation at the International Workshop on Membrane in Kobe 2016 (iMWK2016) (July)

2015

- Keynote presentation at Kobe University Global-Link Forum in Taipei, Taiwan (December)

- Keynote presentation at the International Workshop on Membrane in Kobe 2015 (iWMK2015) (November)
- Keynote presentation at The 8th Sino-US Joint Conference of Chemical Engineering, China (October)
- Keynote presentation at the 2nd Conference on Desalination using Membrane Technology, Singapore (July)
- Keynote presentation at The 9th Conference of Aseanian Membrane Society (AMS9), Taiwan (July)
- Keynote presentation at ICMAT2015 & IUMRS-ICA2015, Singapore (June)
- Keynote presentation at IWA Nano and Water Regional Conference, Dalian University of Technology, China (May)
- Invited talk at the Engineering with Membrane 2015 of Tsinghua University, China (May)
- Invited talk at the 2015 CBME department workshop of the Hong Kong University of Science and Technology, Hong Kong (April)

2014

- Keynote presentation at Kobe University Global-Link Forum in Kuala Lumpur, Malaysia (December)
- Keynote presentation at International Workshop on Membrane in Kobe 2014 (iWMK2014) (November)
- Invited talk at University of Twente, Netherland (October)
- Invited talk at University of Leuven, Belgium (October)
- Keynote presentation at ICOM2014, China (July)
- Invited talk at King Abdullah University of Science and Technology, Saudi Arabia (April)