Pressure-Retarded Osmosis (PRO) for Renewable Osmotic Energy Harvesting: Investigation of Performance-Limiting Factors and their Control Strategies

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ABSTRACT
Pressure-retarded osmosis (PRO), an emerging membrane separation process driven by osmosis, has attracted worldwide attention in recent years for its promising applications in renewable osmotic energy harvesting, waste industrial brine disposal, and low energy seawater desalination. This study systematically investigated the performance-limiting phenomena in PRO – internal concentration polarization (ICP), reverse solute diffusion (RSD), membrane deformation, and membrane fouling. The results revealed that the performance-limiting factors are interrelated with each other and their adverse effects on PRO performance are through the reduction of PRO driving force and membrane properties. ICP occurs within the unstirred membrane support layer and can substantially reduce the effective osmotic pressure across the membrane. It can also increase the membrane fouling tendency. RSD is a unique phenomenon in ODMP. Severe RSD can enhance both ICP and membrane fouling. PRO membrane is subject to deformation due to lack of sufficient mechanical strength to withstand the applied pressure. Membrane deformation can lead to the significant loss of membrane selectivity, which causes more severe RSD and thus RSD-enhanced ICP effect. Membrane fouling, particularly internal fouling within the support layer, can reduce the membrane permeability and enhance the ICP. It is one of the most challenging issues for the practical application of PRO. Based on the understanding of the mechanisms of the PRO performance-limiting effects, several strategies were explored to improve the PRO performance, including feed spacer optimization, reinforced membrane fabrication, membrane modification, and development of novel fouling-mitigation approaches. Finally, based on the fundamental studies on PRO, the efforts and experiences for scaling up the PRO membrane technology in Singapore will be introduced and future research directions will be outlined in this presentation.

ABOUT THE SPEAKER
Dr. Qianhong She is currently a lecturer at The University of Sydney. He received a B.Eng in 2006 from Sichuan University, dual M.Eng in 2009 from Shanghai Jiao Tong University and Nanyang Technological University, and a PhD in 2014 from Nanyang Technological University. Before joining The University of Sydney, he worked as a research associate/research fellow in the Singapore Membrane Technology Centre (SMTC) at Nanyang Technological University from 2010 to 2017. From 2009 to 2010, he worked as an engineer at the PowerChina Huadong Engineering Corporation and served as a technical consultant for a World Bank financed environment project titled “Zhejiang Qiantang River Basin Small Town Environment Project”. Qianhong’s research interests include development of membrane separation technologies for water reuse, seawater desalination and renewable energy harvesting. In particular, he has expertise in osmotically-driven membrane separation processes such as forward osmosis (FO) and pressure-retarded osmosis (PRO). He has published over 20 peer-reviewed papers with over 1200 citations and an h-index of 16 according to Scopus. He has also filed 2 international patents, written 1 book chapter and delivered a number of presentations at international conferences. Qianhong has received several prestigious awards for his academic and research achievement, including the Chinese Government Award for Outstanding Students Abroad, and the Green Talent Award from the German Federal Ministry of Education and Research (BMBF).