

Developing Clean-Tech with Membrane Science and Engineering

An Interview and Site Visit at Professor Neal Chung's Laboratory in National University of Singapore

Abstract:

Professor Neal Chung, the guru of membrane technology, has been actively developing world-class R&D capability in membrane technology in Singapore with focused application in clean-tech. His co-invention in ultrafiltration hollow fibre membrane has been widely adopted by industries for water treatment. His passion and expertise in membrane science and engineering has enabled strong industry partnerships worldwide with various value add benefits. Together with his hard working and world class research team in Singapore, Prof. Chung's research in membrane technology for water reuse and desalination, and gas separation has been adopted by industries. Prof. Chung's group is building capabilities in membrane for life science application. He is currently teaching and conducting his research in National University of Singapore, with total of 40 people under his group. This article shares more insights about his research activities in membrane science and engineering in all three sectors of application: energy, water and life science.

Clean Technology, comprising Clean Energy and Environment & Water, is one important application of nanotechnology that especially was identified to be the national key area of growth of Singapore in 2006. As part of clean technology development, we recognize the importance of membrane technology in contributing to integrated solution for clean energy, environment and water. One of the most important players in membrane technology is Prof Neal Chung (<http://www.chbe.nus.edu.sg/membrane/>), Professor of Chemical and Biomolecular Engineering, National University of Singapore (NUS), and NanoGlobe team had the privilege to interview him and visit his laboratories to learn from him and his team members about their R&D activities and infrastructure set up.

The first fifteen years of Prof Chung's career life was spent in industry (mostly in Hoechst Celanese) from being a research engineer to a research associate/project leader working on various polymeric materials for various applications such as electronics, data storage for military, lithium battery membrane, and gas separation membrane. His next fifteen years, from 1995 to now, have then been spent in Singapore. He was in charge of the Advanced Polymer Group at Institute of Materials Research and Engineering (IMRE) from Program Coordinator to Program Director. He played a vital role in setting up Hyflux's (Singapore leading water technology company) R&D capability in membrane technology development. Prof Chung has also been actively teaching and conducting world-class research in NUS on membrane science and engineering including purification and separation technologies for water, energy (gas and bio-fuel), chemicals and pharmaceuticals (proteins and chiral



drugs).

His extensive knowledge in membrane science and engineering has brought him to diverse applications of membrane with practical benefits to his global industrial partners. In the area of energy development, Prof Chung invented a series of aliphatic diamino-modified polyimides that produce membranes with H₂/CO₂ selectivity far superior to other polymeric membranes. His research group has developed proprietary expertise in fabricating dual-layer hollow fibre membranes for gas separation and develops molecular-level mixed matrix composite membranes for bio-fuel separation. Prof Chung has received substantial funding and international collaborations from British Gas (UK), Universal Oil Products (USA), and Mitsui Chemicals (Japan).

In the area of water reuse and desalination, his group is the first to develop nano-filtration polybenzimidazole (PBI) forward osmosis (FO) membranes with very narrow pore size distribution. Prof Chung's group has made a significant breakthrough in Membrane Distillation (MD) by developing microporous hollow fibres with superior flux using hydrophilic and/or hydrophobic nanoparticles and carbon nanotubes. His global partners in this sector include significant industrial players from PBI Performance Company, Hyflux (Singapore), BASF (Germany), Kureha Corporation (Japan), and KAUST (Saudi Arabia).

Life science is the emerging sector that Prof Chung's group has started building his capabilities on. He has invented novel membrane materials for protein and pharmaceuticals separation. His team has been working with Merck (USA) and BASF (Germany).

The laboratories he is in charge of in NUS are impressive, comprising customized fibre spinning facility that can scale up to industry standard and one of the only four membrane characterization machines in the world: Positron Annihilation Spectroscopy. He has currently total of 40 researchers and students in his research group, forming one of the largest groups in Singapore's and World's universities.

No doubt Prof Chung's capability in membrane science and engineering is one of the best in the world, if not the first. He was part of the team who invented, developed and commercialized Vectra™ liquid crystalline polymers with annual business size of US\$150 million in the 1980s, and was also a co-inventor of Hyflux Kristal™ 600 ultrafiltration hollow fibre membranes which has been commercialized worldwide. Recently he has been awarded Hyflux-SNIC Environment Chemistry Award by Singapore National Institute of Chemistry (SNIC) and IChemE (Institute of Chemical Engineers, UK) in Singapore Awards for Excellence and Innovation in Sustainable Technology. He has received over SGD37M of funding from various organizations globally (about 1/6 from industries and overseas institutes) over the last fifteen years of his career in Singapore.



Prof Neal Chung (2nd from right) and his Research Fellow Dr Natalia Widjojo (center) with NanoGlobe team



Hollow fibre spinning equipment available in Prof Chung's laboratory in NUS