Highly efficient nature-inspired membrane could potentially lower cost of water purification by 30 per cent

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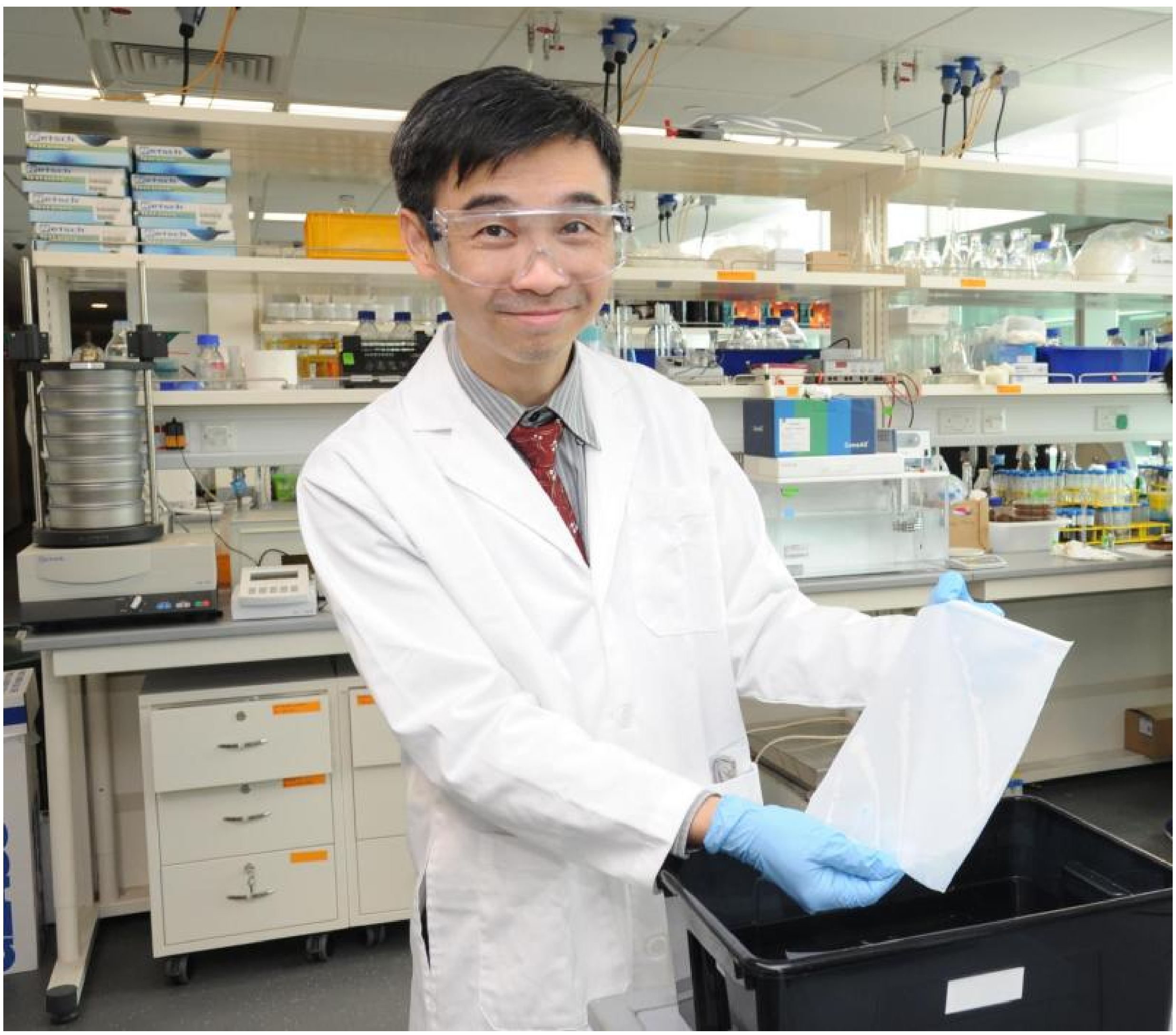

Associate Professor Tong Yen Wah holding up a sample of the novel biomimetic membrane. The membrane is engineered to mimic the layers of cells on the roots of mangrove trees by embedding nano-sized aquaporin-vesicles onto a stable and functional ultrafiltration substrate membrane using surface imprinting technology. Credit: National University of Singapore

The growing demand for potable water calls for low energy and cost effective methods for water purification. Inspired by the natural water purification systems of the roots of the mangrove plant and the human kidney, a team of researchers from the National University of Singapore (NUS) Environmental Research Institute (NERI) has engineered a novel biomimetic membrane that can purify water at low pressure, thus reducing energy costs. This new technology can potentially reduce water purification costs by up to 30 per cent.

The water purification industry today faces a major challenge of high energy costs incurred by current membrane systems to recover water from saline sources. These industrial water purification processes are costly because they require high hydraulic or osmotic pressures to push water molecules to filter through the membrane systems.

Led by Associate Professor Tong Yen Wah who is also from the Department of Chemical and Biomolecular Engineering at the NUS Faculty of Engineering, the team of researchers have designed and fabricated a new aquaporin-incorporated biomimetic membrane water purification and treatment system that is highly efficient. Aquaporins are membrane proteins that selectively conduct water molecules in and out of cells, preventing the passage of ions and other solutes.

Nature's water purification systems

Aquaporins, also known as the water channels in living cell membranes, have been found to be the functional unit of nature's water purification systems. These channels, present in all living things from bacteria to mangrove plants and human kidneys, provide nature's examples of membrane structures that allow high volume of water molecules to pass through a small surface area at very low pressures, leaving impurities like salt behind.

With the presence of aquaporin, the mangrove plant which has adapted to survive in salt water, is able to filter between 90 and 95 per cent of the salt at its roots, while the human kidney is able to purify up to 150 litres of water daily.

Mimicking biological membranes

The NUS team is among the first in the world to have succeeded in placing aquaporin proteins onto polymer membranes to act as channels that allow only water to go through very quickly, at low pressures and low energy.

Explained Assoc Prof Tong, "The biomimetic membrane is constructed to mimic the layers of cells on the roots of mangrove trees by embedding nano-sized aquaporin-vesicles onto a stable and functional ultrafiltration substrate membrane using an innovative yet simple and easy-to-implement surface imprinting technology. We found that the resultant aquaporin-incorporated biomimetic membrane allows water to pass through it faster and also display lower salt leakage than a membrane without aquaporin."

Implications of findings and applications

The team has also observed that the novel membrane exhibits high mechanical strength and stability during the water filtration process unlike conventional biomimetic membranes which tend to be quite fragile. This makes it suitable for industrial applications in water treatment and desalination. For the public, this could mean greater supply of drinking water at much lower costs in the near future.

The team is currently in discussions with an American-based company to develop a pilot-scale module to test the feasibility of the membranes in the next two years.

According to Assoc Prof Tong, the team's technique of producing the biomimetic membranes can be applied in biological and biomedical research where the study of any other biological membrane protein requires its unique characteristics and functions to be expressed and properly placed onto synthetic membranes.

In fact, the team is also currently in discussions with AWAK Technologies to engineer similar biomimetic membranes for incorporation into wearable kidney dialysis devices. The future wearable kidney dialysis machines may work without any adsorbents and may also be much more compact in size.

Provided by National University of Singapore

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