Biomimetic Membranes for Water Purification

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Problem

Scarcity of clean water leads to disease, death and often international tension. In many parts of the world, access to potable water is limited. The clean water supply faces further stresses due to its required use in a number of industrial processes. Desalination, the process of making fresh water from seawater, is used around the world to increase the supply of fresh water where water is scarce, but the process can be costly. Reverse osmosis (RO) is currently the best method of desalination, but the energy requirements and costs for this process are tremendous and offset the benefits. Australia has met its water supply demand with freshwater dams and water catchments in the past, but has been unable to do so in the last decade due to a significant lack of rainfall. As a result, Australia has come to rely on desalination for providing fresh water. At the Perth Seawater Desalination Plant, over half of the energy budget is used to establish the pressure drop needed to push the water through a semi-permeable membrane. By optimizing ion exclusion while facilitating rapid water transport, the amount of energy required to push fluid through the membrane can be reduced and drawbacks of current methods can be mitigated.

Innovative Edge

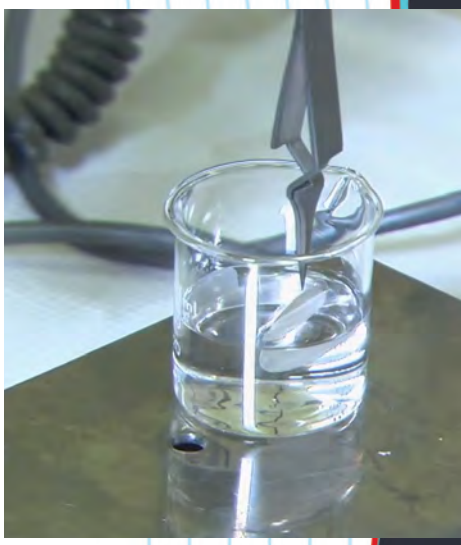
Inspired by how the human body filters water, Sandia, in conjunction with the University of New Mexico, has developed a synthetic biomimetic membrane that can be used for water desalination that requires significantly less energy than any other RO membrane on the market. Project lead Susan Rempe, Sandia, stated, "… our initial membranes achieved a 10-fold improvement in water purification efficiency compared with state-of-the-art RO membranes."

By combining experimental and multi-scale modeling techniques of natural biological channels, the science of the interface between water samples, ions, and pores was investigated to determine the molecular structure-function relationships pertinent to water desalination. Based on the results, the selective new membranes were created by combining evaporation-induced self-assembly of nanopores with atomic layer deposition (ALD), allowing specific tuning of both pore size and surface chemistry. By controlling these two elements, ion exclusion can be optimized while maximizing the flow of water through the pore channel.

Commercialization and Industry Impact

The principal application of biomimetic membranes is water purification. Based on performances observed in small-scale studies, the improved water flux of these membranes is predicted to reduce excess energy costs by 88%, translating into an annual $1.45M savings for a modest 100 mL/day desalination plant. Potential further applications of the membrane technology include liquid and gas separations, carbon dioxide capture and removal, and lithium-ion battery technology.

The biomimetic membrane technology is patent pending and further development is currently underway. This technology has great commercial potential and Sandia is working to identify companies interested in bringing the product to market.



Nanoporous biomimetic membrane on a nanostructured support used for water desalination testing.