Hold the salt: Engineers develop revolutionary new desalination membrane

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(PhysOrg.com) -- The new reverse-osmosis membrane resists the clogging that typically occurs when seawater and brackish water are purified.

Researchers from the UCLA Henry Samueli School of Engineering and Applied Science have unveiled a new class of reverse-osmosis membranes for desalination that resist the clogging which typically occurs when seawater, brackish water and waste water are purified.

The highly permeable, surface-structured membrane can easily be incorporated into today's commercial production system, the researchers say, and could help to significantly reduce desalination operating costs. Their findings appear in the current issue of the Journal of Materials Chemistry.

Reverse-osmosis (RO) desalination uses high pressure to force polluted water through the pores of a membrane. While water molecules pass through the pores, mineral salt ions, bacteria and other impurities cannot. Over time, these particles build up on the membrane's surface, leading to clogging and membrane damage. This scaling and fouling places higher energy demands on the pumping system and necessitates costly cleanup and membrane replacement.

The new UCLA membrane's novel surface topography and chemistry allow it to avoid such drawbacks.

"Besides possessing high water permeability, the new membrane also shows high rejection characteristics and long-term stability," said Nancy H. Lin, a UCLA Engineering senior researcher and the study's lead author. "Structuring the membrane surface does not require a long reaction time, high reaction temperature or the use of a vacuum chamber . The anti-scaling property, which can increase membrane life and decrease operational costs, is superior to existing commercial membranes."

The new membrane was synthesized through a three-step process. First, researchers synthesized a polyamide thin-film composite membrane using conventional interfacial polymerization. Next, they activated the polyamide surface with atmospheric pressure plasma to create active sites on the surface. Finally, these active sites were used to initiate a graft polymerization reaction with a monomer solution to create a polymer "brush layer" on the polyamide surface. This graft polymerization is carried out for a specific period of time at a specific temperature in order to control the brush layer thickness and topography.

"In the early years, surface plasma treatment could only be accomplished in a vacuum chamber," said Yoram Cohen, UCLA professor of chemical and biomolecular engineering and a corresponding author of the study. "It wasn't practical for large-scale commercialization because thousands of meters of membranes could not be synthesized in a vacuum chamber. It's too costly. But now, with the advent of atmospheric pressure plasma, we don't even need to initiate the reaction chemically. It's as simple as brushing the surface with plasma, and it can be done for almost any surface."

In this new membrane, the polymer chains of the tethered brush layer are in constant motion. The chains are chemically anchored to the surface and are thus more thermally stable, relative to physically coated polymer films. Water flow also adds to the brush layer's movement, making it extremely difficult for bacteria and other colloidal matter to anchor to the surface of the membrane.

"If you've ever snorkeled, you'll know that sea kelp move back and forth with the current or water flow," Cohen said. "So imagine that you have this varied structure with continuous movement. Protein or bacteria need to be able to anchor to multiple spots on the membrane to attach themselves to the surface — a task which is extremely difficult to attain due to the constant motion of the brush layer. The polymer chains protect and screen the membrane surface underneath."

Another factor in preventing adhesion is the surface charge of the membrane. Cohen's team is able to choose the chemistry of the brush layer to impart the desired surface charge, enabling the membrane to repel molecules of an opposite charge.

The team's next step is to expand the membrane synthesis into a much larger, continuous process and to optimize the new membrane's performance for different water sources.

"We want to be able to narrow down and create a membrane selection system for different water sources that have different fouling tendencies," Lin said. "With such knowledge, one can optimize the membrane surface properties with different polymer brush layers to delay or prevent the onset of membrane fouling and scaling.

"The cost of desalination will therefore decrease when we reduce the cost of chemicals [used for membrane cleaning], as well as process operation [for membrane replacement]. Desalination can become more economical and used as a viable alternate water resource."

Cohen's team, in collaboration with the UCLA Water Technology Research (WaTeR) Center, is currently carrying out specific studies to test the performance of the new membrane's fouling properties under field conditions.

"We work directly with industry and water agencies on everything that we're doing here in water technology," Cohen said. "The reason for this is simple: If we are to accelerate the transfer of knowledge technology from the university to the real world, where those solutions are needed, we have to make sure we address the real issues. This also provides our students with a tremendous opportunity to work with industry, government and local agencies."

A paper providing a preliminary introduction to the new membrane also appeared in the Journal of Membrane Science last month.

Provided by University of California Los Angeles

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