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PRESS RELEASE

A scale-up nanoporous membrane centrifuge for reverse osmosis desalination without fouling

April 9, 2018 — A novel design of a scale-up nanoporous membrane centrifuge (see Figure 1 (a) (b) (c), and (d)) is proposed for reverse osmosis desalination, and the proof of concept is demonstrated through large scale molecular dynamics simulations reported in this article.

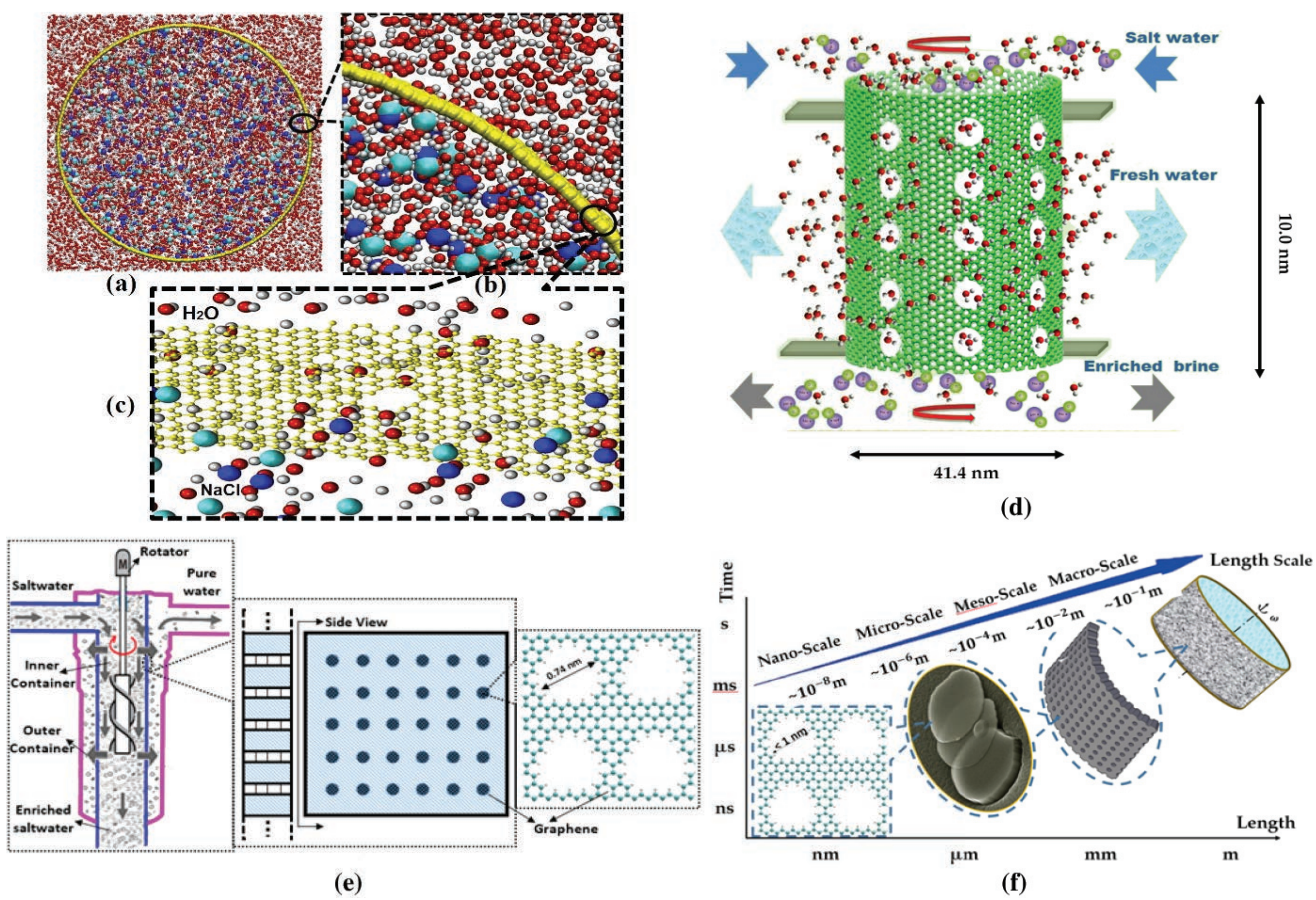

Figure 1. *Design and Proof of Concept of nano-porous membrane centrifuge: (a), (b), and (c) nanoscale details of water molecules and Na^+/Cl^- ions at vicinity of graphene membrane; (d) illustration rotational configure working principle; (e) design of a macroscale porous membrane centrifuge, and (f) multiscale pore structure on the centrifuge wall.*

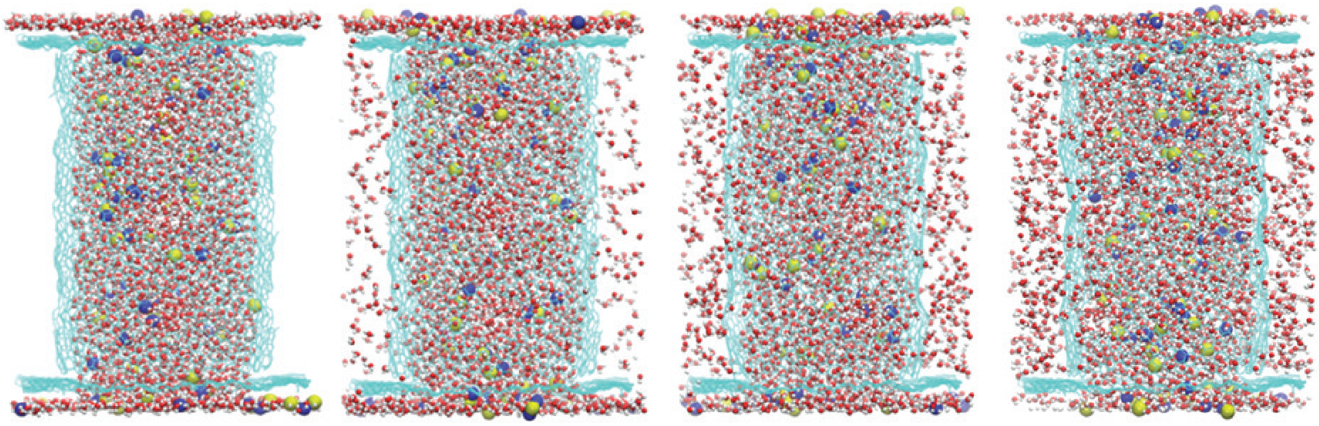

Figure 2. *Proof of concept: Molecular dynamics simulation of reverse osmosis desalination at nanoscale. Time sequence of a nanoscale porous membrane centrifuge in operation: (a), (b), (c), and (d).*

Nanomaterial-based separation membrane technology has been hailed as the game-changer in desalination technology, however, there are two major obstacles to prevent it in real applications: (1) the scale-up challenge, i.e. how to make a macroscale desalination machine with nano-porous membrane, and (2) the fouling problem, i.e. how to prevent Na^+ and Cl^- ions blocking the nanoscale size pore without consuming much energy. In this work, a team of researchers, mainly consisting of graduate and undergraduate students from the University of California-Berkeley, have constructed an ingenuous design of a scaled-up desalination centrifuge (**see Figure 1**) that is decorated with nanoscale porous membrane. The nanoscale porous membrane patches are part of the multiscale pore structure on the centrifuge wall (see Figure 1 (e)(f)), so that it can be readily fabricated for industrial scale desalination operation.

Moreover, in this work, we have conducted a large scale molecular dynamics simulation to demonstrate the molecular mechanism of the desalination process, providing the proof of concept of the novel design. The molecular dynamics simulation has convincingly demonstrated that the centrifugal force can balance the osmosis force and provide the thrust of water filtering through nanoscale pores. Furthermore, by using treating the rotating fluid in the centrifuge as the Couette flow, the critical angular velocity of the centrifuge is derived in the first time for such class of desalination machines or centrifuge. The molecular dynamics simulation results substantiated the critical angular velocity derived from the continuum scale fluid mechanics.

More significantly, the research team has found that there is almost no fouling for the desalination centrifuge during the simulation (**see Figure 2**). It is found that the ion concentration does not go up when approaching to the membrane wall, instead, it goes down, because of the combination effects of the Coriolis force and salt rejection of the graphene membrane wall, which hints a great potential for such nano-porous membrane centrifuge. The report will be published in the March 2018 issue of journal *TECHNOLOGY*. As the PI of the project, Professor Shaofan Li of UC Berkeley, said,

> "Amid climate change and water-energy sustainability issues, the proposed nano-membrane centrifuge is a ground-breaking desalination technology with a self-cleaning mechanism and a significantly enhanced energy efficiency. Our preliminary results indicate that the graphene membrane centrifuge has a great potential to scale up and becomes the model for the next generation industrial desalination devices."

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