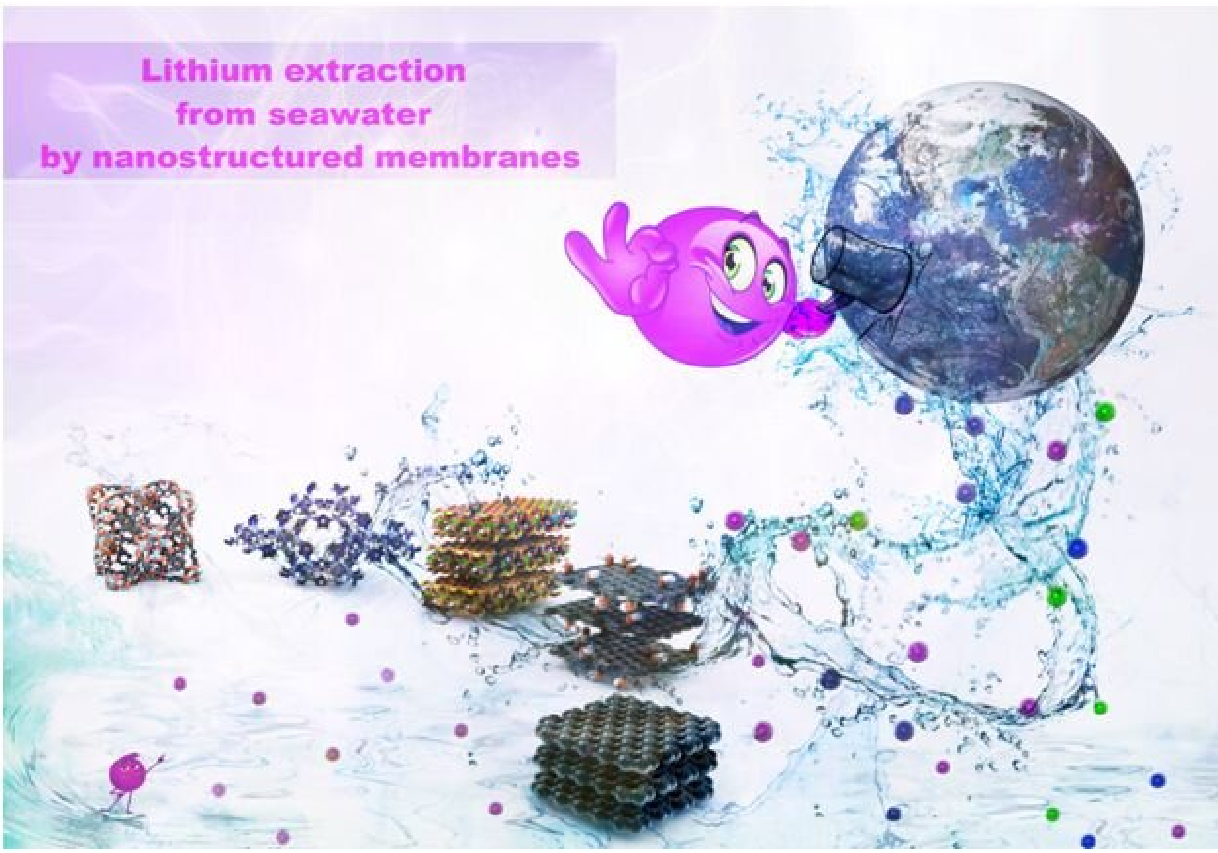
Lithium extraction from seawater by nanostructured membranes

January 20 2020, by Asghar Habibnejad Krayem



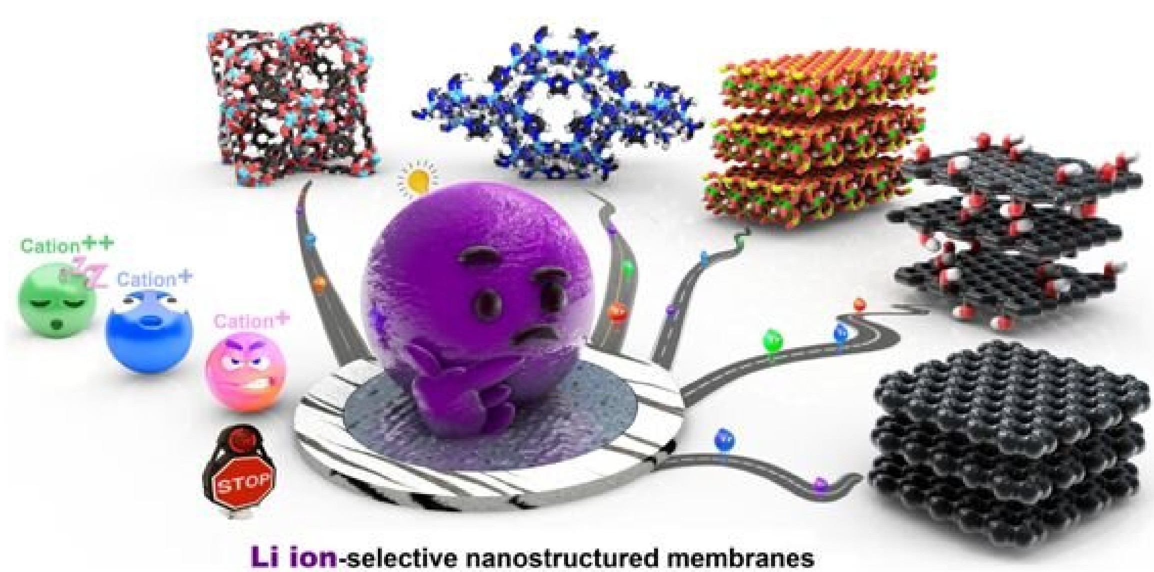
Lithium extraction from seawater by the new types of the membrane in nanoscales. Credit: Ehsan Hosseini, Iran University of Science and Technology

Researchers predict that the supply of the energy-critical element lithium will soon be less than its continuously increasing demand, which will make lithium a strategically influential element. The amount of Li+ in seawater is estimated to be nearly 230,000 million tons, almost 57,000 times higher than its land abundance. Lithium consumption has been increasing substantially worldwide from 265,000 tons in 2015 to an estimated 498,000 tons in 2025.

This sharp increase in Li demand is predominantly due to the extensive use of Li-ion batteries or electronic devices. Indeed, over the course of five years from 2010 to 2015, the consumption of Li-ion batteries leaped from 4.6 to 7 billion units. Currently, the main sources of Li+ supply are brine deposits and lithium ores, which are reported to amount to approximately 34 million tons worldwide. While these Li+ reserves are sufficient to address current market demands, the conventional technologies to extract Li+ from resources are either difficult or require high-cost investment, and suppliers will struggle to meet future market demands. Furthermore, a major bottleneck is the distribution of conventional resources of Li+ around the globe, with many deposits in less accessible regions. In comparison, the Li+ reserves in seawater represent an unconventional resource of Li+ that is not limited by geographic boundary. However, Li+ seawater processing is complicated due to the low concentration of Li+ and the coexistence of chemically similar ions such as Na+ and K +. Therefore, the development of new processing technologies with enhanced product yields is urgently needed.

In a new review article in *Nature Communications*, a team of international researchers including Iranian and Australian researchers from University of Isfahan, Iran University of Science and Technology, University of New South Wales, University of Queensland and Macquarie University have come together to provide an in-depth review on the opportunities, progress and challenges of design materials for the development of membranes with nanochannels and nanopores with Li selectivity. They have provided insights into how and why design materials may overcome current challenges posed by the existing technology and how they can enhance both device component function and performance to boost the features of future technologies in the areas of nanomembranes, lithium batteries and desalination applications.

For purification applications, they have reviewed the fundamental concepts relevant to ion transport within nanopores and nanochannels, in addition to discussing the key principles of materials design for the development of membranes with nanochannels and nanopores with Li selectivity. In particular, the advanced materials can serve as building blocks for novel membranes with Li+ ion selectivity and high permeability. It is well known that ions behave drastically differently in confined nanoscale environments, as compared with their behavior in bulk solutions. This unexpected and surprising phenomenon in nanochannels and nanopores, along with the special characteristics of Li+, serves as an important impetus to design Li+-selective membranes. In the bigger picture, they show how challenges such as nanochannel size, nanochannel surface charge and nanochannel morphology can increase or decrease the rate of lithium selectivity.



Performance of lithium selectivity in the variety of nanomembranes. Credit: Ehsan Hosseini, Iran University of Science and Technology

The authors suggest that future efforts should be focused on: (1) improving the fundamental understanding of Li+ ion transport mechanisms in nanochannels with extensive theoretical modeling to support experimental results and to guide materials design, (2) making the Li+ ion-selective membrane materials more stable, reversible and durable, (3) improving Li+/Na+ or Li+/K+ selectivities without compromising Li+ ion transportation rate, (4) developing Li+ ion-selective thin films on flexible polymeric substrates, and (5) introducing new, inexpensive materials that can serve as building blocks for Li+ ion-selective membranes. The strong scientific and strategic goals that underpin the need for improved Li+ ion separation methods will ensure that this field continues to grow in importance.

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More information: Amir Razmjou et al. Design principles of ion selective nanostructured membranes for the extraction of lithium ions, *Nature Communications* (2019). DOI: 10.1038/s41467-019-13648-7