A faster, more efficient nanodevice to filter proton and alkaline metal ions

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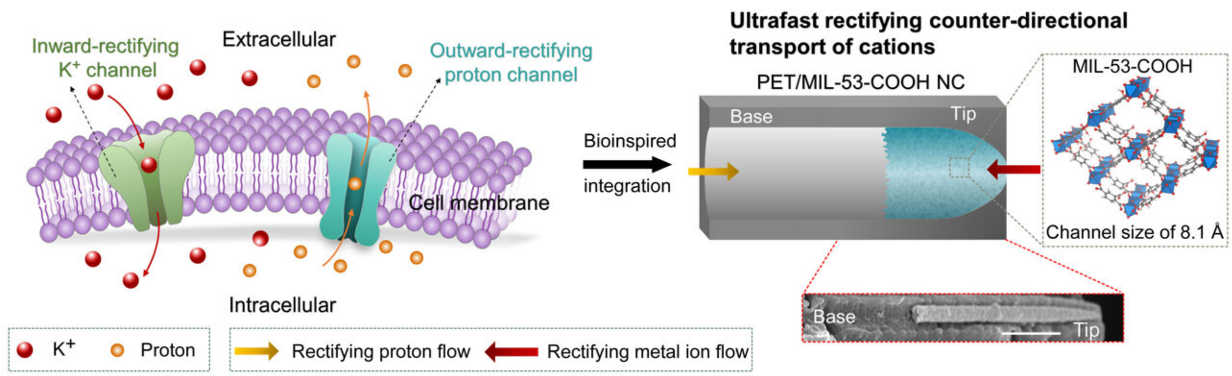

Ultrafast rectifying counter directional transport of cations. Credit: Professor Huanting Wang, Department of Chemical and Biological Engineering, Monash Centre for Membrane Innovation, Monash University

Monash University researchers have developed a faster, more efficient nanodevice to filter proton and alkaline metal ions which will help design next-generation membranes for clean energy technology, conversion and storage.

The new nanodevice works with atomic-scale precision, while generating its own power through reverse electrodialysis.

In the paper published in the journal *Science Advances*, a team of researchers led by Australian Laureate Fellow Professor Huanting Wang from Monash University has found that a metal-organic framework (MIL-53-COOH)-polymer nanofluidic device mimics the functions of both biological inward-rectifying potassium channels and outward-rectifying proton channels.

"It has important real-world implications, particularly for designing next-generation membranes for clean energy technology, energy conversion and storage, sustainable mining and manufacturing, with specific applications in acid and mineral recovery," says Professor Wang, who led the project with research fellow Dr. Jun Lu from Monash University's Department of Chemical and Biological Engineering.

Potassium channels are the most widely distributed type of ion channels and are found in virtually all living organisms. Directional ultrafast transport of ions with atomic-scale precision is one of the core functions of biological ion channels in cell membranes.

These biological ion channels cooperatively maintain the electrolyte and pH balance across cell membranes, which are essential for the physiological activities of the cells.

For example, the electrolyte concentration disorder in cells, especially for the positively charged ions such as potassium, sodium and proton, is recognized to have a direct link with some diseases such as epilepsy.

Inspired by these functions, artificial nanochannel devices constructed from porous materials have been widely studied for the experimental investigation of nanofluidic ion transport to achieve the ion-specific transport properties observed in biological ion channels.

For instance, carbon nanotubes, graphene, polymers and metal-organic frameworks (MOFs) have been used to construct nanometer-sized pores to mimic atomic-scale ionic and molecular transport of biological ion channels.

However, the discovery of bioinspired ultrafast rectifying counter-directional transport of proton and metal ions has not been reported until now.

"The unprecedented ion-specific rectifying transport behavior found in our metal-organic framework (MIL-53-COOH)-polymer nanofluidic device is attributed to two distinct mechanisms for metal ions and proton, explained by theoretical simulations. This work furthers our knowledge of designing artificial ion channels, which is important to the fields of nanofluidics, membrane and separations science," says Professor Wang.

"This is an exciting fundamental finding and we hope it stimulates more research into these important areas," says Professor Wang.

More information: Jun Lu et al, Ultrafast rectifying counter-directional transport of proton and metal ions in metal-organic framework–based nanochannels, *Science Advances* (2022). DOI: 10.1126/sciadv.abl5070

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