Ultrathin nanosheets separate ions from water

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Credit: Levi Xu

In a world-first, an international research team, led by Monash University and ANSTO, has created an ultrathin porous membrane to completely separate potentially harmful ions, such as lead and mercury, from water.

This innovation could enhance the desalination process and transform the dirtiest water into something potable for millions of people across the world. The membrane performed steadily for more than 750 hours using limited energy. It could also be manufactured on a global scale, pending further testing.

Researchers for the first time developed water-stable monolayer aluminium tetra-(4-carboxyphenyl) porphyrin frameworks (termed AI-MOFs) nanosheets, and demonstrated their near perfection as building materials for membranes in ion separation from water.

These Al-MOFs nanosheets, exfoliated to just a nanoscale in thickness, can help remove harmful carcinogens from the atmosphere by creating highly porous membranes to facilitate the separation processes of gases and organic solvents, such as paint.

Results from the study are published in *Science Advances*.

The study was led by Professor Xiwang Zhang, Researcher in the Department of Chemical Engineering at Monash University and the Director of the ARC Research Hub for Energy-efficient Separation, and Dr. Qinfen Gu, Principal Scientist at ANSTO's Australian Synchrotron.

"Owing to the rich porosity and uniform pore size, Metal Organic Frameworks (MOFs) offer significant advantages over other materials for the precise and fast membrane separation," Professor Zhang said.

"However, it remains a daunting challenge to fabricate ultrathin MOFs membranes (less than 100 nanometres) for water-related processing, since most reported MOFs membranes are typically thick and suffer from insufficient hydrolytic stability.

"In this world-first study, we were able to use these ultrathin Al-MOFs to create a membrane that is permeable to water while achieving maximum porosity with nearly 100 percent rejection of ions. This study shows promise for the future application of this membrane to other filtration processes, such as gas separation."

Polymers are by far the most widespread membrane materials, largely owing to their easy processability and low cost, the study suggests.

However, traditional polymeric membranes for ion separation from water usually contain a dense selective layer, leading to limited selectivity. In contrast, nanoporous membranes, where uniform nanopores act as the sieving role, may overcome this limitation.

This breakthrough study confirms that the intrinsic nanopores of Al-MOFs nanosheets facilitate the ion/water separation by creating vertically-aligned channels as the main transport pathway for water molecules, and was enabled by the unique capability of the Australian Synchrotron to analyse materials at the molecular level.

"We use an instrument called the Powder Diffraction beamline at ANSTO's Australian Synchrotron, to understand the difference between the molecular structure of nanosheet samples, and samples at different temperatures, in order to test water purification performance," Dr. Gu said.

"The technique, called in-situ, high temperature powder X-ray diffraction characterisation, was conducted on the nanosheets, and during the process there were no obvious variations in the samples at increasing temperature, demonstrating their robustness."

More information: Meipeng Jian et al. Ultrathin water-stable metal-organic framework membranes for ion separation, *Science Advances*

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