Oil separation made easier with 2-D material membrane

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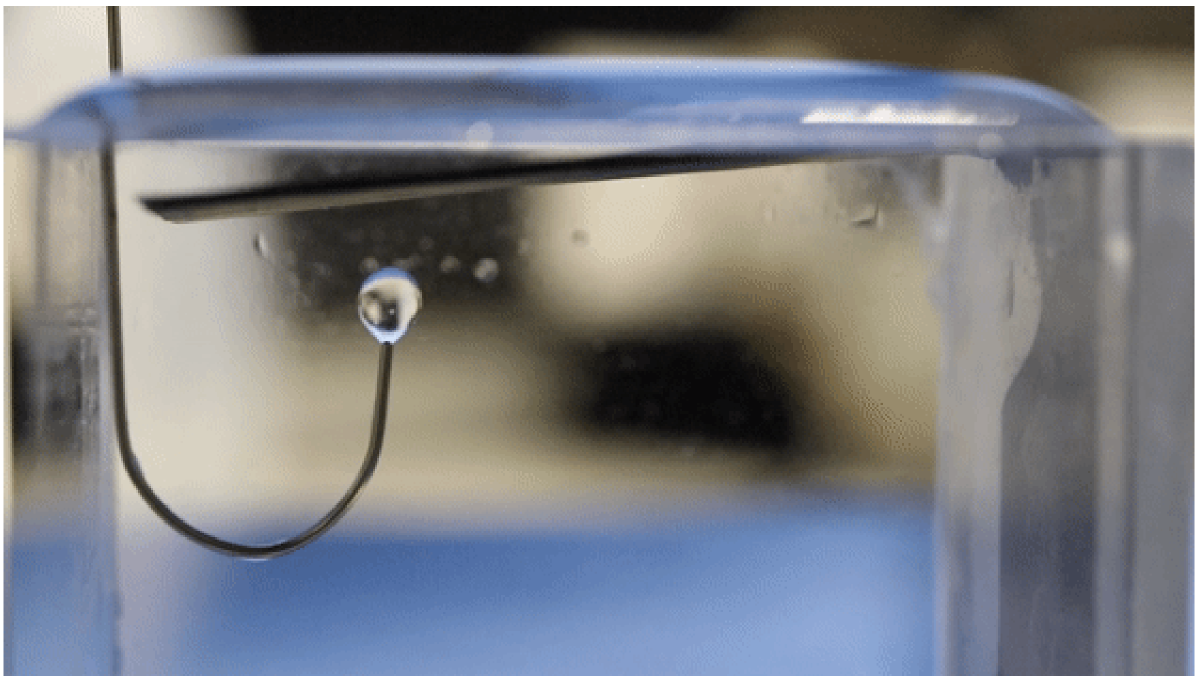

Credit: University of Manchester

University of Manchester researchers have made a leap forward in overcoming one of the biggest problems in membrane technology- membrane fouling.

Membrane-based separations are essential for various processes, such as water filtration and oil and gas separation. The use of graphene and other 2-D materials in membrane technology has attracted significant attention due to the tunability of these materials making it possible to filter impurities previously not thought possible.

Fouling is an inevitable event in membrane separation, where blockages occur in the pores of a membrane, stopping the flow and preventing the membrane from functioning normally. Fouling is an especially severe issue for oil separation technology due to how easily the oil droplets stick onto the membrane surface.

Published in *Nature Communications*, the team based in the Department of Chemical Engineering & Analytical Science, Henry Royce Institute and the National Graphene Institute in collaboration with University College London (UCL), have demonstrated that the exfoliated two-dimensional form of vermiculite, a natural clay mineral, can be used as a fouling resistant coating for oil-water separation.

It is well known that increasing the water wettability and decreasing the oil adhesion on a membrane can reduce membrane fouling due to oil deposition. The scientific community has in the past mainly focused on tuning the surface charge of the membrane by chemical modification to enhance the water wettability and hence reduce fouling. These attempts have succeeded in part, but long-term antifouling properties were yet to be attained.

Now the team at The University of Manchester have found that the wetting properties of vermiculite membranes, prepared by stacking many layers of two-dimensional vermiculite sheets, can be tuned from super-hydrophilic to hydrophobic simply by exchanging the cations present on the surface and between the layers of vermiculite.

Further, the team also demonstrated how to exploit this unusual property for reducing the membrane fouling during oil-water filtration by using superhydrophilic lithium exchanged vermiculite (lithium vermiculite) as a coating layer for commercial microfiltration membranes.

Dr. Kun Huang, the lead author of the paper said: "Lithium vermiculite membranes not only provide superhydrophilicity but also repel oil droplets during filtration due to their underwater superoleophobic property. The under-water oil adhesion on vermiculite coated microfiltration membranes was more than 40 times lower than the noncoated membrane."

Credit: University of Manchester

The demonstrated oil-water separation is just one example of the use of super-hydrophilic antifouling membranes. Their application could be expanded to other areas such as developing self-cleaning surfaces, and antifouling filters for biofiltration.

Professor Rahul Raveendran Nair said: "Developing antifouling membranes for oil-water separation is a long-sought objective for scientists and technologists, which is evident from the rapid growth in the number of publications in this area. We believe our work provides a major advance in the fundamental understanding of wetting properties of solids down to the molecular level and is a notable milestone in the development of robust fouling resistant membrane technologies."

The work was done in collaboration with scientists from the Department of Physics & Astronomy at UCL to probe the mechanism of the unusual water wetting transition in the vermiculite membrane upon ion exchange.

Patrick Rowe, from UCL said: "Our study shows how the atomic-scale details of the interaction between water molecules, surfaces and ions are important for understanding the surface properties of solids. The high water affinity and hence lower oil droplet interaction of the lithium vermiculite is due to the unique arrangement of water molecules on the surface of lithium vermiculite."

Dr. Christie Cherian, who co-authored the paper said, "The presence of ions in the vermiculite membrane helped to pin the water molecules firmly on the surface even when the membrane is exposed to oil for a prolonged period of time, a property unique to the vermiculite coated membrane, shows promise for using it as a long-term antifouling coating.

Provided by University of Manchester

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