Shear genius: Researchers find way to scale up wonder material, which could do wonders for the Earth

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Researchers at the University of Virginia School of Engineering and Applied Science have figured out how to take a miracle material, one capable of extracting value from captured carbon dioxide, and do what no one else has: make it practical to fabricate for large-scale application.

The breakthrough from chemical engineering assistant professor Gaurav "Gino" Giri's lab group has implications for the cleanup of the greenhouse gas, a major contributor to the climate change dilemma. It could also help solve the world's energy needs.

The substance, called MOF-525, is in a class of materials called metal-organic frameworks.

"If you can make these MOFs cover large areas, then new applications become possible, like making a membrane for carbon capture and electrocatalytic conversion all in one system," Giri said.

Electrocatalytic conversion creates a bridge from renewable energy sources to direct chemical synthesis, taking the burning of carbon dioxide-producing fossil fuels out of the equation.

What gives MOFs superpowers is their ultra-porous, crystalline structures—3D networks of minute nanoscale cavities that create vast internal surface area and act like a sponge—that can be designed to trap all sorts of chemical compounds.

A cutting-edge solution

Giri's group reasoned that starting with an inherently scalable synthesis technique—solution shearing—would better their odds. They had already had success shearing simpler MOFs.

In Giri's process, the MOF's components are mixed in a solution, then spread across a substrate with the shearing blade. As the solution evaporates, chemical linkages form the MOF as a thin film on the substrate. Applying MOF-525 in this way produces an all-in-one membrane for carbon trapping and conversion.

"The bigger the membrane, the more surface area you have for the reaction, and the more product you could get," said Prince Verma, a December 2023 Ph.D. graduate from Giri's lab. "With this process, you can increase the shearing blade width to whatever size you need."

The team targeted CO_2 conversion to demonstrate their solution shearing approach because carbon capture is widely used to reduce industrial emissions or to remove it from the atmosphere—but at a cost to operators with minimal return on the investment: Carbon dioxide has little commercial value and most often winds up stored indefinitely underground.

However, with minimal energy input, using electricity to catalyze a reaction, MOF-525 can take away an oxygen atom to make carbon monoxide—a chemical that is valuable for manufacturing fuels, pharmaceuticals and other products.

The researchers published their findings in the American Chemical Society journal *Applied Materials and Interfaces*. Also contributing to the work were Connor A. Koellner, Hailey Hall, Meagan R. Phister, Kevin H. Stone, Asa W. Nichols, Ankit Dhakal and Earl Ashcraft.

More information: Prince K. Verma et al, Solution Shearing of Zirconium (Zr)-Based Metal–Organic Frameworks NU-901 and MOF-525 Thin Films for Electrocatalytic Reduction Applications, *ACS Applied Materials & Interfaces* (2023). DOI: 10.1021/acsami.3c12011

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