# New polymer membrane tech improves efficiency of carbon dioxide capture

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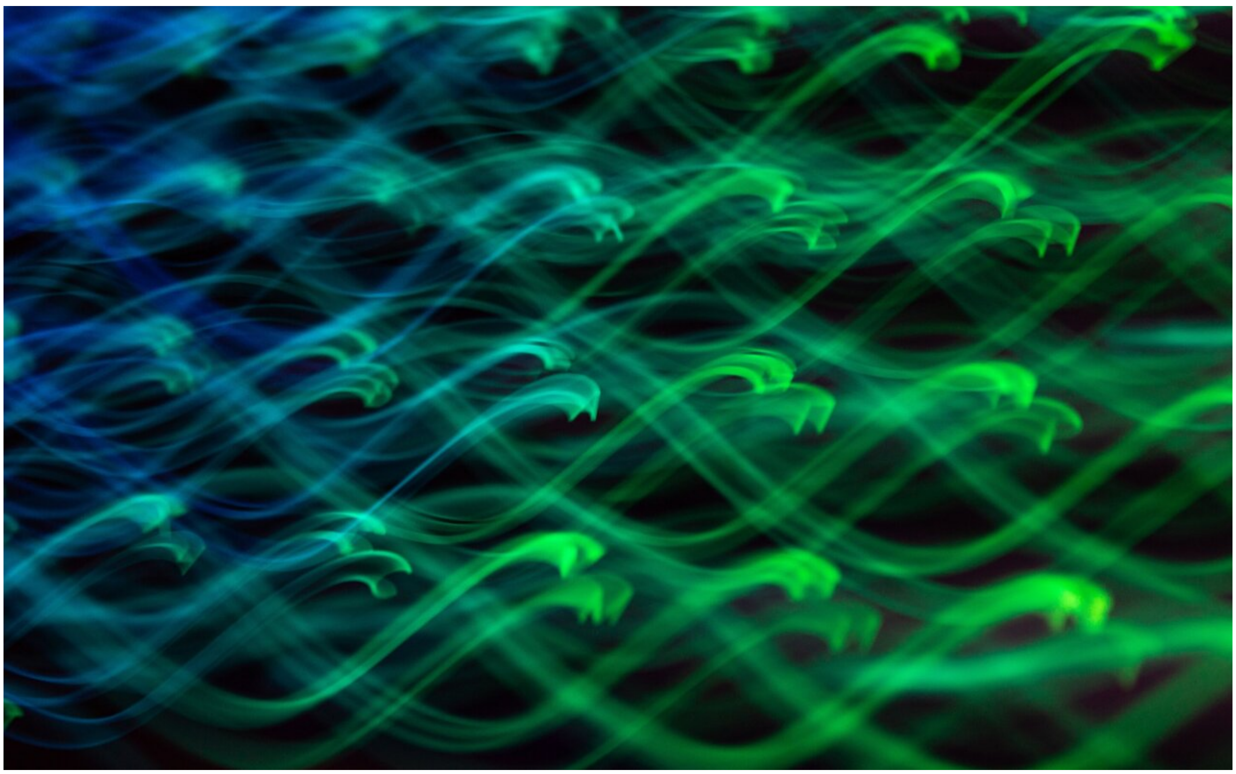

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Researchers have developed a new membrane technology that allows for more efficient removal of carbon dioxide ($CO_2$) from mixed gases, such as emissions from power plants.

"To demonstrate the capability of our new membranes, we looked at mixtures of $CO_2$ and nitrogen, because $CO_2$/nitrogen dioxide mixtures are particularly relevant in the context of reducing greenhouse gas emissions from power plants," says Rich Spontak, co-corresponding author of a paper on the work. "And we've demonstrated that we can vastly improve the selectivity of membranes to remove $CO_2$ while retaining relatively high $CO_2$ permeability."

"We also looked at mixtures of $CO_2$ and methane, which is important to the natural gas industry," says Spontak, who is a Distinguished Professor of Chemical and Biomolecular Engineering and Professor of Materials Science & Engineering at North Carolina State University. "In addition, these $CO_2$-filtering membranes can be used in any situation in which one needs to remove $CO_2$ from mixed gases—whether it's a biomedical application or scrubbing $CO_2$ from the air in a submarine."

Membranes are an attractive technology for removing $CO_2$ from mixed gases because they do not take up much physical space, they can be made in a wide variety of sizes, and they can be easily replaced. The other technology that is often used for $CO_2$ removal is chemical absorption, which involves bubbling mixed gases through a column that contains a liquid amine—which removes $CO_2$ from the gas. However, absorption technologies have a significantly larger footprint, and liquid amines tend to be toxic and corrosive.

These membrane filters work by allowing $CO_2$ to pass through the membrane more quickly than the other constituents in the mixed gas. As a result, the gas passing out the other side of the membrane has a higher proportion of $CO_2$ than the gas entering the membrane. By capturing the gas passing out of the membrane, you capture more of the $CO_2$ than you do of the other constituent gases.

A longstanding challenge for such membranes has been a trade-off between permeability and selectivity. The higher the permeability, the more quickly you can move gas through the membrane. But when permeability goes up, selectivity goes down—meaning that nitrogen, or other constituents, also pass through the membrane quickly—reducing the ratio of $CO_2$ to other gases in the mixture. In other words, when selectivity goes down you capture relatively less $CO_2$.

The research team, from the U.S. and Norway, addressed this problem by growing chemically active polymer chains that are both hydrophilic and $CO_2$-philic on the surface of existing membranes. This increases $CO_2$ selectivity and causes relatively little reduction in permeability.

"In short, with little change in permeability, we've demonstrated that we can increase selectivity by as much as about 150 times," says Marius Sandru, co-corresponding author of the paper and senior research scientist at SINTEF Industry, an independent research organization in Norway. "So we're capturing much more $CO_2$, relative to the other species in gas mixtures."

Another challenge facing membrane $CO_2$ filters has been cost. The more effective previous membrane technologies were, the more expensive they tended to be.

"Because we wanted to create a technology that is commercially viable, our technology started with membranes that are already in widespread use," says Spontak. "We then engineered the surface of these membranes to improve selectivity. And while this does increase the cost, we think the modified membranes will still be cost effective."

"Our next steps are to see the extent to which the techniques we developed here could be applied to other polymers to get comparable, or even superior, results; and to upscale the nanofabrication process," Sandru says. "Honestly, even though the results here have been nothing short of exciting, we haven't tried to optimize this modification process yet. Our paper reports proof-of-concept results."

The researchers are also interested in exploring other applications, such as whether the new membrane technology could be used in biomedical ventilator devices or filtration devices in the aquaculture sector.

The researchers say they are open to working with industry partners in exploring any of these questions or opportunities to help mitigate global climate change and improve device function.

The paper is published in the journal *Science*.

**More information:** Marius Sandru et al, An integrated materials approach to ultrapermeable and ultraselective $CO_2$ polymer membranes, *Science* (2022). DOI: 10.1126/science.abj9351

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