Lab turns hard-to-process plastic waste into carbon-capture master

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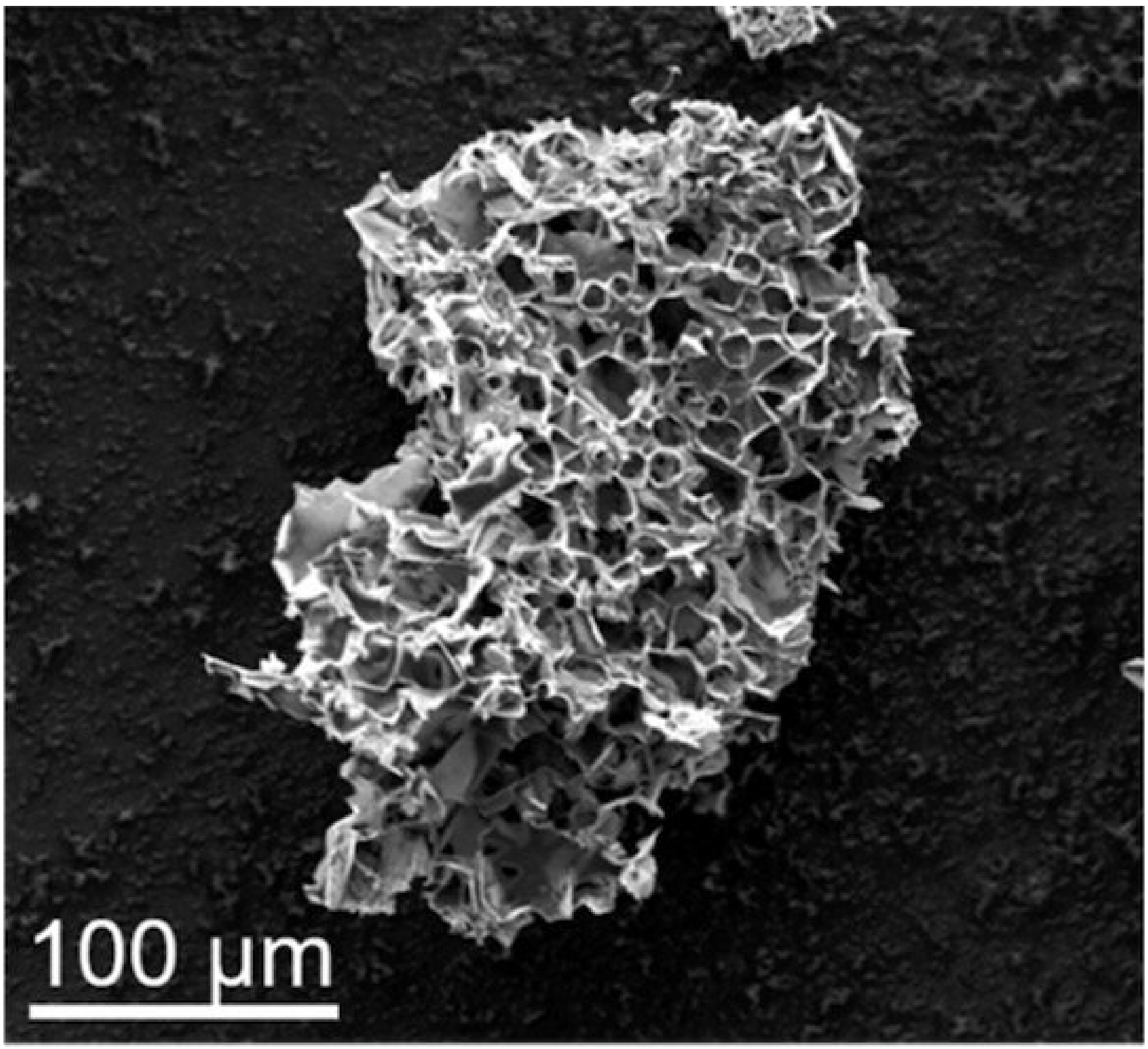

Pores in this micron-scale particle, the result of pyrolyzing in the presence of potassium acetate, are able to sequester carbon dioxide from streams of flue gas. Credit: Tour Group, Rice University

Here's another thing to do with that mountain of used plastic: make it soak up excess carbon dioxide.

What seems like a win-win for a pair of pressing environmental problems describes a Rice University lab's newly discovered chemical technique to turn waste plastic into an effective carbon dioxide (CO_2) sorbent for industry.

Rice chemist James Tour and co-lead authors Rice alumnus Wala Algozeeb, graduate student Paul Savas and postdoctoral researcher Zhe Yuan reported in the American Chemical Society journal *ACS Nano* that heating plastic waste in the presence of potassium acetate produced particles with nanometer-scale pores that trap carbon dioxide molecules.

These particles can be used to remove CO_2 from flue gas streams, they reported.

"Point sources of CO_2 emissions like power plant exhaust stacks can be fitted with this waste-plastic-derived material to remove enormous amounts of CO_2 that would normally fill the atmosphere," Tour said. "It is a great way to have one problem, plastic waste, address another problem, CO_2 emissions."

A current process to pyrolyze plastic known as chemical recycling produces oils, gases and waxes, but the carbon byproduct is nearly useless, he said. However, pyrolyzing plastic in the presence of potassium acetate produces porous particles able to hold up to 18% of their own weight in CO_2 at room temperature.

Graduate student Paul Savas feeds raw plastic into a crusher to prepare it for pyrolysis, or heating in an inert atmosphere. Credit: Jeff Fitlow, Rice University

In addition, while typical chemical recycling doesn't work for polymer wastes with low fixed carbon content in order to generate CO_2 sorbent, including polypropylene and high- and low-density polyethylene, the main constituents in municipal waste, those plastics work especially well for capturing CO_2 when treated with potassium acetate.

The lab estimates the cost of carbon dioxide capture from a point source like post-combustion flue gas would be $21 a ton, far less expensive than the energy-intensive, amine-based process in common use to pull carbon dioxide from natural gas feeds, which costs $80-$160 a ton.

A plastic jug is fodder for a material developed at Rice University that turns waste plastic into a material that absorbs carbon dioxide. The lab is targeting flue gases that now require a far more complex process to sequester carbon dioxide. Credit: Jeff Fitlow/Rice University

Like amine-based materials, the sorbent can be reused. Heating it to about 75 degrees Celsius (167 degrees Fahrenheit) releases trapped carbon dioxide from the pores, regenerating about 90% of the material's binding sites.

Because it cycles at 75 degrees Celsius, polyvinyl chloride vessels are sufficient to replace the expensive metal vessels that are normally required. The researchers noted the sorbent is expected to have a longer lifetime than liquid amines, cutting downtime due to corrosion and sludge formation.

To make the material, waste plastic is turned into powder, mixed with potassium acetate and heated at 600 C (1,112 F) for 45 minutes to optimize the pores, most of which are about 0.7 nanometers wide. Higher temperatures led to wider pores. The process also produces a wax byproduct that can be recycled into detergents or lubricants, the researchers said.

More information: Wala A. Algozeeb et al, Plastic Waste Product Captures Carbon Dioxide in Nanometer Pores, *ACS Nano* (2022). DOI: 10.1021/acsnano.2c00955

Provided by Rice University

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