Crystal sponges excel at sopping up CO2

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Since the Industrial Revolution, levels of carbon dioxide---a major contributor to the greenhouse effect---have been on the rise, prompting scientists to search for ways of counteracting the trend. One of the main strategies is removing carbon dioxide (CO_2) from the flue exhaust of power plants, using porous materials that take up the gas as it travels up the flue.

A new class of materials invented and developed by Omar Yaghi at the University of Michigan can store vast amounts of carbon dioxide. And one member of the class has the highest carbon dioxide capacity of any porous material, Yaghi and co-worker Andrew Millward report in a paper published online Dec. 1 in the *Journal of the American Chemical Society*.

The materials, called metal-organic frameworks (MOFs) and sometimes referred to as crystal sponges, previously have been shown to have great potential for storing hydrogen and methane. On the molecular level, MOFs are scaffolds made up of metal hubs linked together with struts of organic compounds, a structure designed to maximize surface area.

Just one gram of a MOF, in fact, has the surface area of a football field. By modifying the rods in various ways, Yaghi and his team have been able to increase the material's storage capacity, making it possible to stuff more gas molecules into a small area without resorting to high pressure or low temperature.

Yaghi compares the principle by which MOFs store CO_2 to placing a honeycomb in a room full of bees. "All the bees will come to the honeycomb, so you're able to contain a large number of bees in a small volume. What we've created is a material that acts like a honeycomb for adsorbing carbon dioxide."

The star performer in Yaghi's cast of MOFs is one dubbed MOF-177, which sops up 140 percent of its weight in CO_2 at room temperature and reasonable pressure (32 bar).

Put another way, "if you have a tank filled with MOFs, you can store in that tank as much carbon dioxide as would be stored in nine tanks that do not contain MOFs," Yaghi said. By comparison, a tank filled with porous carbon---one of the current state-of-the-art materials for capturing CO_2 in power plant flues---would hold only four tanks worth of CO_2.

MOFs can be made in large quantities from low-cost ingredients, such as zinc oxide---a common component of sunblock---and terephthalate, which is used in plastic soda bottles. And finding effective, low-cost ways of reducing CO_2 emissions is crucial, said Yaghi, who is the Robert W. Parry Collegiate Professor of Chemistry.

"Almost every region of the world is using more energy than ever before, and the prediction is that this will continue to increase, not just for petroleum, but also for coal and natural gas. Whenever you're burning fossil fuels, you're releasing CO_2 into the atmosphere, with devastating environmental effects that include melting the polar ice caps and changing the ocean's acidity. In the United States alone, each person is responsible for generating more than 15 tons of carbon dioxide a year, largely from automobile and power plant emissions," Yaghi said.

"I'm not exaggerating when I say that we are digging a big, black hole for ourselves by not addressing the problem of carbon dioxide emissions."

Source: University of Michigan