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# Synthetic Stones Capture Carbon

Materials Science: Researchers manipulate limestone chemistry to increase its capacity for trapping carbon dioxide

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While scrubbers in smokestacks at coal plants can pull out toxic gases like sulfur dioxide, scientists haven't yet developed a cost-effective technology to remove carbon dioxide from industrial exhaust. Now European researchers have tinkered with the chemical composition of limestone to produce a material that absorbs almost twice as much $CO_2$ as the natural mineral can (*Environ. Sci. Technol.*, DOI: 10.1021/es2034697).

Small-scale carbon-scrubbing operations currently rely on amine-based materials. But these materials lose some of their absorbency after repeated use. Dolomitic limestone, $CaMg(CO_3)_2$, is an alternative. As early as the 1970s, scientists noticed that when they heated it, the mineral could absorb $CO_2$ from the mixture of gases emitted by coal power plants and later release it as a purified gas, ready to compress and store. It doesn't absorb as much $CO_2$ as amine-based materials, but it can survive more absorption-release cycles.

To improve on dolomitic limestone's carbon-absorbing properties, Christoph Müller of the Swiss Federal Institute of Technology, Zurich (ETH), and his colleagues wanted to minimize the amount of magnesium in the material. Magnesium helps form microscopic pores in the mineral, which expose more surface area of the calcium component to $CO_2$. But magnesium doesn't react with $CO_2$. With more of the element, the limestone becomes heavier and requires more heat to drive the calcium to react with $CO_2$.

So Müller and his colleagues created a series of synthetic limestones by mixing different ratios of calcium and magnesium, precipitating the mineral with different bases, and using different crystallization times. They found that a calcium-to-magnesium ratio of about 7:3, precipitation with a nitrate base, and 14 days of crystallization produced the best-performing material.

Per gram of material, the material absorbed about 0.56 g of $CO_2$, while natural dolomitic limestone absorbs 0.38 g $CO_2$. The synthetic material also performed better after repeated cycles of absorption and release. After 15 such cycles, a gram of the synthetic limestone could still grab about 0.51 g of $CO_2$, while the natural mineral could absorb only 0.26 g.

When the scientists studied the best-performing synthetic mineral's crystal structure using a scanning electron microscope, they found that the magnesium and calcium atoms were mixed evenly throughout the crystal lattice, similar to dolomitic limestone's structure. Meanwhile, in the poor-performing materials, the two elements formed separate mini-crystals. The team speculates that the precipitation technique and crystallization time allowed the material to form more pores despite the low amount of magnesium.

Carlos Abanades, a chemical engineer at the National Coal Institute in Oviedo, Spain, says that the material is promising and adds that the researchers next should test whether a scaled-up version of the material will cost less than existing amine technologies.

Edward J. Anthony, a chemical engineer at the University of Ottawa, calls the study "very intriguing work." He says the next step will be to test whether the new material performs as well after even more cycles and in the hot conditions found in industrial settings. Müller says his team plans to test the material under those conditions.

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