Researchers create salts for cheap and efficient CO2 capture

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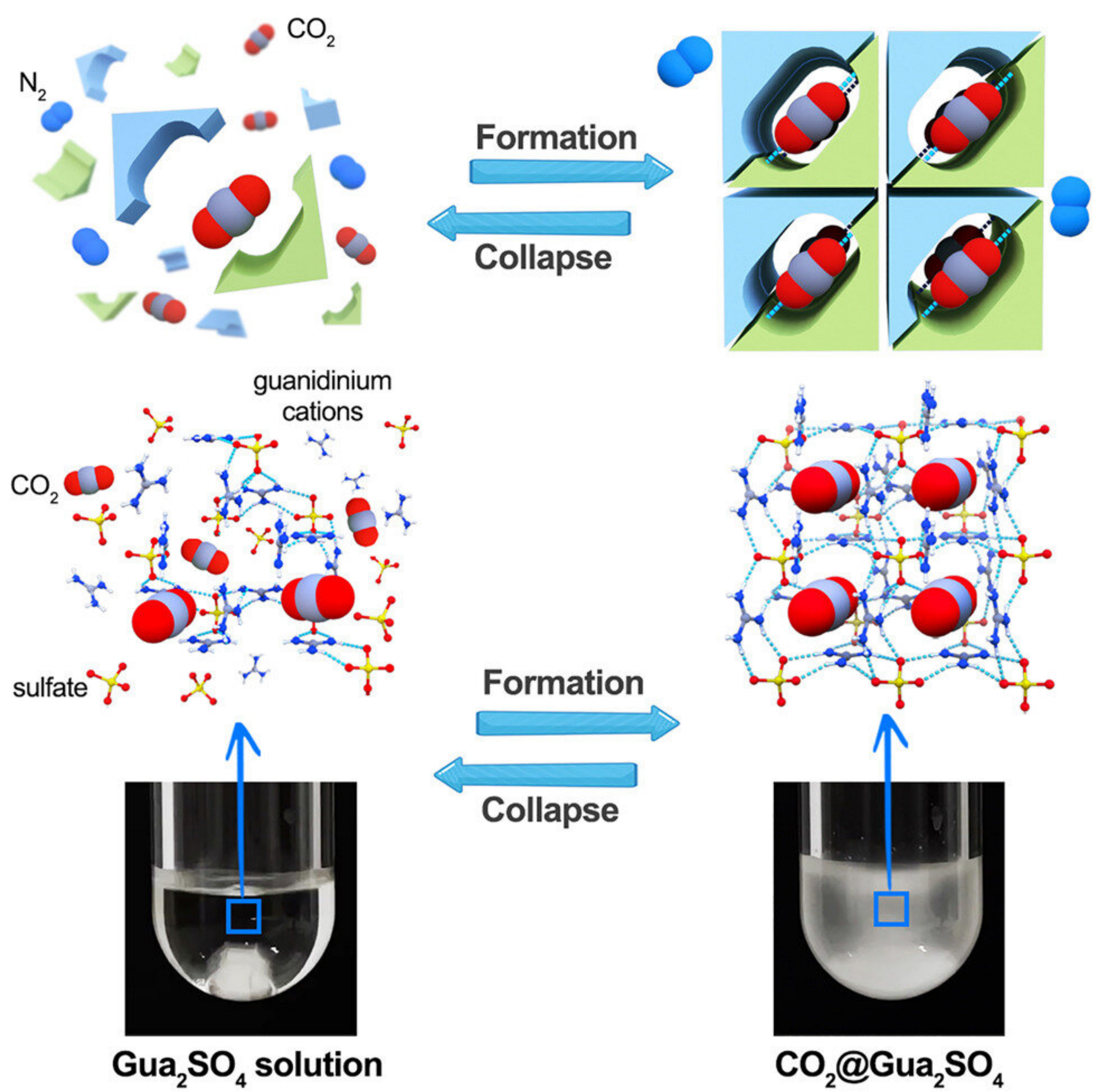

Graphical abstract. Credit: *Cell Reports Physical Science* (2023). DOI: 10.1016/j.xcrp.2023.101383

A team of international researchers led by Professor Cafer T. Yavuz of King Abdullah University of Science and Technology (KAUST), Prof. Bo Liu from University of Science and Technology of China (USTC), and Prof. Qiang Xu of Southern University of Science and Technology (SUSTech) have developed a promising method for carbon capture and storage.

Methane hydrate is studied for its ability to capture and trap gas molecules such as carbon dioxide under high pressure. However, it is difficult to impossible to recreate these conditions in the lab, and the approach is additionally energy intensive, as the methane-ice solid requires refrigeration. Using a salt—guanidinium sulfate—the scientists have successfully created lattice-like structures called clathrates that effectively mimic the methane hydrate activity, trapping the CO_2 molecules and resulting in an energy efficient way to contain the greenhouse gas.

"The guanidinium sulfate serves to organize and trap the CO_2 molecules without reacting with them," said Cafer Yavuz, professor of chemistry, and director of the KAUST Oxide and Organic Nanomaterials for Energy & Environment (ONE) Laboratory. "We have discovered a rare example of a clathrate that is stable and non-corrosive at ambient temperature and pressure, a highly desirable feature compared with ethanol amine, ammonia and other solutions that are commonly used in carbon capture."

Previous carbon capture methods included chemisorption, where chemical bonds form between CO_2 molecules and the surface. This process worked well; however, the chemical bonds require energy to break them down, which drives up the cost of the CO_2 capture operation. The salt-based, clathrate structure utilizes low energy, physisorption processes while capturing CO_2 without water or nitrogen interference, opening a promising venue for future carbon capture and storage technologies through rapid CO_2 solidification.

The discovery introduces a new way of storing and transporting carbon dioxide as a solid. CO_2 is conventionally carried as a solid in the form of dry ice; compressed in gas cylinders; or in the form of carbonates. The salt clathrate allows CO_2 to be carried as a solid powder, yielding remarkably high volume per weight capacity, making this method the least energy intensive, with tremendous potential for real life applications.

"Our team made it possible to carry CO_2 in a solid form without the need for refrigeration or pressure. You will be able to literally shovel CO_2 loaded solids from now on," he said. "The impact is wide and strong, as the global fuel industry and the Kingdom entities are actively looking for ways to capture, store and transport CO_2 without significant energy penalties."

The method could have a significant impact on the fight against climate change, enabling energy-efficient carbon capture and storage. The research team is optimistic that their findings will lead to further improvements in CO_2 capture in terms of stability, recyclability, sorption capacity and selectivity, and lowering regeneration energy penalty and cost.

The research was carried out at Southern University of Science and Technology, University of Science and Technology of China, and King Abdullah University of Science and Technology. The research findings have been published in the journal *Cell Reports Physical Science*.

More information: Zhiling Xiang et al, Synthesis of stable single-crystalline carbon dioxide clathrate powder by pressure swing crystallization, *Cell Reports Physical Science* (2023). DOI: 10.1016/j.xcrp.2023.101383

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