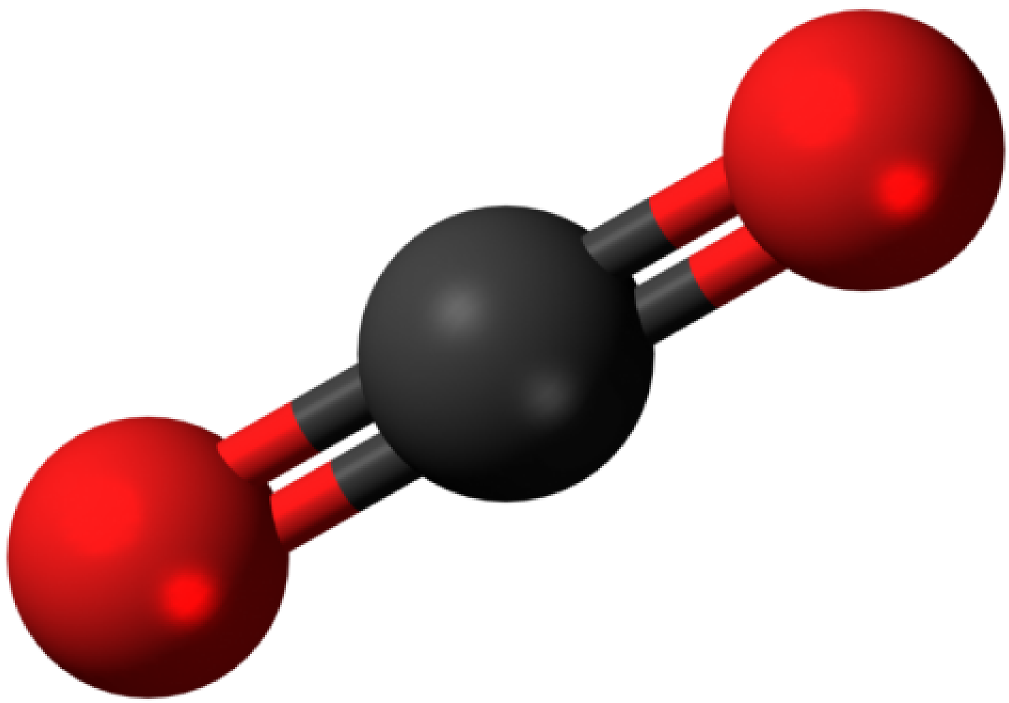
Tech Xplore

Surveilling carbon sequestration: A smart collar to sense leaks

December 13 2022, by Mollie Rappe



Ball-and-stick model of carbon dioxide. Credit: Wikipedia

Sandia National Laboratories engineers are working on a device that would help ensure captured carbon dioxide stays deep underground—a critical component of carbon sequestration as part of a climate solution.

Carbon sequestration is the process of capturing CO_2—a greenhouse gas that traps heat in the Earth's atmosphere—from the air or where it is produced and storing it underground. However, there are some technical challenges with carbon sequestration, including making sure that the CO_2 remains underground long term.

Sandia's wireless device pairs with tiny sensors to monitor for CO_2 leaks and tell above-ground operators if one happens—and it lasts for decades.

"The world is trying a whole lot of different ways to reduce the production of CO_2 to mitigate climate change," said Andrew Wright, Sandia electrical engineer and project lead.

"A complementary approach is to reduce the high levels of CO_2 in the atmosphere by collecting a good chunk of it and storing it deep underground. The technology we're developing with the University of Texas at Austin aims to determine whether the CO_2 stays down there. What is special about this technology is that we'll be monitoring it wirelessly and thus won't create another potential path for leakage like a wire or fiber."

Storing and sensing CO_2

In carbon sequestration, CO_2 would typically be stored 3,000 to 12,000 feet below the surface in an area that once contained oil, gas or water, Wright said. A hole would be bored down through an impermeable layer of rock called cap rock that can prevent CO_2 from percolating up toward the surface.

Pressurized CO_2 heated to around 175 degrees Fahrenheit would be pumped down this borehole. In some cases, it will be heated up to prevent it from freezing when it expands into the area, Wright said. Once the storage area is full, the borehole would be plugged, and in some cases, the trapped CO_2 would react with the rock and bind permanently.

The team, led by geoscientist David Chapman at UT Austin, plans to embed glitter-sized CO_2 sensors, about an 1/8 of an inch by an 1/8 of an inch, in the concrete surrounding the borehole, above and below the cap rock layer. Electrical engineer Axel Scherer at the California Institute of Technology is leading the group making the glitter-sized CO_2 sensors.

Chemist Jeff Mecham at the Research Triangle Institute is leading the group making a coating to protect the sensors from the harsh environment of concrete, while still allowing CO_2 to reach the sensors.

Sandia's role is to make an electronic device that charges the CO_2 sensors, receives information from them about the presence or absence of CO_2 and sends that information up to operators at the surface. This device, called a smart collar, needs to work for 20 to 40 years, Wright said.

Making a smart collar

The communication with the CO_2 sensors works like the radio-frequency identification chip in a tap-to-pay credit card, Wright said. The smart collar emits energy at one radio frequency to power the CO_2 sensors. The sensors collect data on the amount of CO_2 around them and send that information to the smart collar at a different radio frequency.

"There's no power or battery in your credit card," Wright said. "Instead, when you tap it onto the reader at the supermarket, the reader energizes the chip. The chip relays some information to the reader, and that's what allows you to buy your groceries."

One of the biggest technical challenges the team had to overcome was the fact that RFID chips aren't designed to be embedded in concrete, said Alfred Cochrane, another Sandia electrical engineer on the project.

In order to power the sensors through concrete, the team needs to "shine" very intense radio waves of a certain frequency at the sensors. However, much of these radio waves reflect off the concrete, drowning out any information from the sensors at that frequency, Cochrane said. He suggested they try to power the sensors with one frequency and then use far less intense radio waves of a different frequency to query the sensors and receive information back from them. This worked well in their tests, he added.

Recently, the Sandia team successfully showed the smart collar prototype powering and communicating with off-the-shelf RFID chips embedded in an inch of cement, a major component of concrete. For the smart collar to last for decades, the team designed the prototype to use supercapacitors to store power rather than batteries that only last for a couple of years. Next, the team will test the smart collar prototype with Caltech's CO_2 sensing chips.

The Sandia team has also tested powering and communicating with their smart collar prototype through 160 feet of commercially available wired pipe. This pipe has coaxial cable, very similar to that used in cable TV, embedded within it, so that the system won't need any other wires or cables that could introduce new escape routes for the CO_2, Cochrane said.

Later next year, the goal is to demonstrate the whole system—Caltech's chips and Sandia's smart collar—first at Sandia's above-ground testing facility and then at UT Austin's underground test facility. UT Austin geoscientist Mohsen Ahmadian is the lead for the underground testing part of the project.

While the focus of this project is on carbon sequestration, the technology could also be used to monitor storage areas for natural gas or even hydrogen, Wright said.

"There's way too much CO_2 in the atmosphere right now and it's only getting worse," Cochrane said. "Along with all the other technologies like renewable energy, carbon sequestration is an active approach to mitigating climate change. If you capture carbon from a coal-fired power plant or a cement plant and store it indefinitely, you could make those processes carbon neutral or even allow us to go carbon negative and remove more CO_2 than we emit."

Provided by Sandia National Laboratories

Citation: Surveilling carbon sequestration: A smart collar to sense leaks (2022, December 13) retrieved 26 April 2024 from
https://techxplore.com/news/2022-12-surveilling-carbon-sequestration-smart-collar.html