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Escalating CO_2 and It's Squestration Strategies

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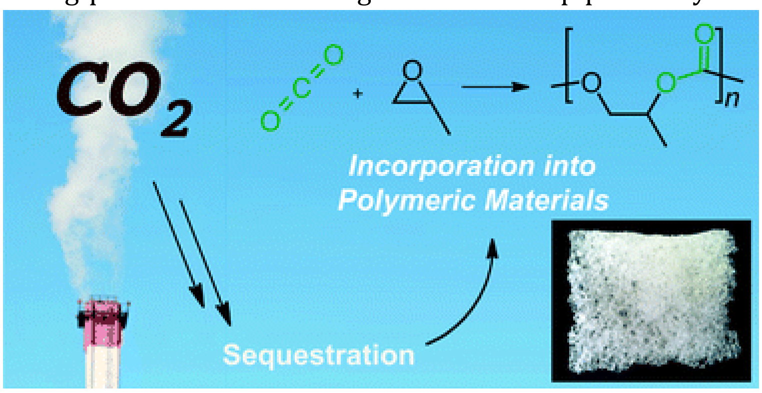
In pre-industrial times, every million molecules of air contained about 280 molecules of carbon dioxide. Today that proportion exceeds 380 molecules per million, and it continues to climb. Evidence is mounting that carbon dioxide's heat-trapping power has already started to boost average global temperatures. If carbon dioxide levels continue upward, further warming could have dire consequences, resulting from rising sea levels, agriculture disruptions, and stronger storms (e.g. hurricanes) striking more often. But choking off the stream of carbon dioxide entering the atmosphere does not have a simple solution. Fossil fuels, which provide about 85 percent of the world's energy, are made of hydrocarbons, and burning them releases huge quantities of carbon dioxide. Even as renewable energy sources emerge, fossil-fuel burning will remain substantial. And the fossil fuel in greatest supply — coal — is the worst carbon dioxide emitter per unit of energy produced. A grand challenge for the 21st century's engineers will be developing systems for capturing the carbon dioxide produced by burning fossil fuels and sequestering it safely away from the atmosphere.

Carbon sequestration is capturing the carbon dioxide produced by burning fossil fuels and storing it safely away from the atmosphere. Methods already exist for key parts of the sequestration process. A chemical system for capturing carbon dioxide is already used at some facilities for commercial purposes, such as beverage carbonation and dry ice manufacture. The same approach could be adapted for coal-burning electric power plants, where smokestacks could be replaced with absorption towers. One tower would contain chemicals that isolate carbon dioxide from the other gases (nitrogen and water vapor) that escape into the air and absorb it. A second tower would separate the carbon dioxide from the absorbing chemicals, allowing them to be returned to the first tower for reuse.

A variation to this approach would alter the combustion process at the outset, burning coal in pure oxygen rather than ordinary air. That would make separating the carbon dioxide from the exhaust much easier, as it would be mixed only with water vapor, and not with nitrogen. It's relatively simple to condense the water vapor, leaving pure carbon dioxide gas that can be piped away for storage. In this case, though, a different separation problem emerges — the initial need for pure oxygen, which is created by separating it from nitrogen and other trace gases in the air. If that process can be made economical, it would be feasible to retrofit existing power plants with a pure oxygen combustion system, simplifying and reducing the cost of carbon dioxide capture.



Advanced methods for generating power from coal might also provide opportunities for capturing carbon dioxide. In coal-gasification units, an emerging technology, coal is burned to produce a synthetic gas, typically containing hydrogen and carbon monoxide. Adding steam, along with a catalyst, to the synthetic gas converts the carbon monoxide into additional hydrogen and carbon dioxide that can be filtered out of the system. The hydrogen can be used in a gas turbine (similar to a jet engine) to produce electric power. Several underground possibilities have been investigated.

Logical places include old gas and oil fields. Storage in depleted oil fields, for example, offers an important economic advantage — the carbon dioxide interacts with the remaining oil to make it easier to remove. Some fields already make use of carbon dioxide to enhance the recovery of hard-to-get oil. Injecting carbon dioxide dislodges oil trapped in the pores of underground rock, and carbon dioxide's presence reduces the friction impeding the flow of oil through the rock to wells.

Depleted oil and gas fields do not, however, have the capacity to store the amounts of carbon dioxide that eventually will need to be sequestered. By some estimates, the world will need reservoirs capable of containing a trillion tons of carbon dioxide by the end of the century. That amount could possibly be accommodated by sedimentary rock formations with pores containing salty water (brine).The best sedimentary brine formations would be those more than 800 meters deep — far below sources of drinking water, and at a depth where high pressure will maintain the carbon dioxide in a high-density state. Sedimentary rocks that contain brine are abundantly available, but the concern remains whether they will be secure enough to store carbon dioxide for centuries or millennia. Faults or fissures in overlying rock might allow carbon dioxide to slowly escape, so it will be an engineering challenge to choose, design, and monitor such storage sites carefully.

Concerns about leaks suggest to some experts that the best strategy might be literally deep-sixing carbon dioxide, by injecting it into sediments beneath the ocean floor. High pressure from above would keep the carbon dioxide in the sediments and out of the ocean itself. It might cost more to implement than other methods, but it would be free from worries about leaks. And in the case of some coastal sites of carbon dioxide production, ocean sequestration might be a more attractive strategy than transporting it to far-off sedimentary basins. It is also possible that engineers will be able to develop new techniques for sequestering carbon dioxide that are based upon natural processes. For example, when atmospheric concentrations of carbon dioxide increased in geologic times to a certain unknown threshold, it went into the ocean and combined with positively charged calcium ions to form calcium carbonate – limestone. Similarly, engineers might devise ways of pumping carbon dioxide into the ocean in ways that would lock it eternally into rock. It may well be that multiple strategies and storage locations will be needed to solve this problem, but the prospect for success appears high. "Scientific and economic challenges still exist," writes Harvard geoscientist Daniel Schrag, "but none are serious enough to suggest that carbon capture and storage will not work at the scale required to offset trillions of tons of carbon dioxide emissions over the next century."

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