

Microbial-driven atmospheric CO₂ conversion for large-scale carbon sequestration

Stanford scientists have developed a method that utilizes specialized microbes to capture and convert dilute atmospheric carbon dioxide into reduced organic compounds. This innovative technology, capable of metabolizing CO₂ at low, atmospheric concentrations, offers a promising approach to large-scale carbon sequestration, potentially contributing to global efforts to remove tens of gigatons of carbon dioxide annually by 2030.

Carbon dioxide (CO₂) is a primary contributor to global warming, with atmospheric concentrations steadily increasing due to human activities. Traditional CO₂ capture methods often require energy-intensive processes to concentrate and convert the gas, and there are limited end uses for CO₂, reducing incentive for CO₂ capture and limiting the large-scale applicability. Biological systems, particularly CO₂-respiring microbes, offer a promising alternative due to their ability to metabolize CO₂ at low concentrations and ambient conditions. Unlike energy-intensive chemical processes, these commonly anaerobic microorganisms can directly capture and convert dilute CO₂ into useful organic compounds, operating efficiently in moderately alkaline solutions at ambient temperatures and pressures. Understanding the mechanisms of microbial CO₂ metabolism and the conditions that facilitate it could lead to the development of efficient, large-scale carbon capture and conversion technologies.

Preliminary experiments with the microbial CO₂ capture and conversion system demonstrated successful production of reduced carbon compounds from indoor air. Importantly, the system consumed CO₂ to levels below average atmospheric concentrations at sea level, indicating effective carbon sequestration. These results suggest that the microbial technology is capable of both capturing and converting dilute atmospheric CO₂. Consequently, this approach has the potential to

significantly contribute to global carbon sequestration efforts and transform climate change mitigation strategies by offering a sustainable method to remove CO₂ from the atmosphere while producing valuable organic compounds.

Stage of Development:

Proof of Concept

Continued research – Operation of the technology in a continuous system at a larger scale. Optimize process to maximize energetic conversion and efficiency. Identifying microbial ecologies to mediate and enhance the robustness of the process.

Applications

- Large-scale atmospheric carbon dioxide removal
- Production of valuable reduced organic compounds
- Integration with industrial processes for on-site carbon capture and utilization

Advantages

- Captures and converts CO₂ at low, atmospheric concentrations from gas or aqueous streams
- Operates at ambient temperatures and pressures, reducing energy requirements
- Tolerant to common industrial gas impurities like hydrogen sulfide and sulfur oxides
- Potential for continuous operation without the need for regeneration steps

Patents

- Published Application: [20250207156](#)

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