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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 CO_2 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 CO_2 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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