

Docket #: S24-356

Production of Carbon Material from Low Concentration CO₂ via Microbial CO₂ Reduction and Pyrolysis

Stanford researchers have developed a novel pathway to upcycle waste CO₂ into graphitic carbon nanomaterials. Addressing the urgent challenge of rising atmospheric CO₂ levels, this process transforms dilute CO₂ streams, such as air or flue gases, into an industrially valuable product. Carbon nanomaterials do not readily decompose and can therefore act as semi-permanent carbon storage depending on end-use.

The pathway uniquely integrates biological and thermochemical transformations. It pioneers the use of microbes for CO₂ conversion directly from CO₂ captured in alkaline solution. Powered by H₂, biotrickling filters with alkaliphilic hydrogenotrophic methanogenic archaea and hydrogen-oxidizing bacteria convert CO₂ to methane. The produced methane is then pyrolyzed to form carbon. Compared to alternative CO₂ capture and use pathways, this pathway avoids intermediate product separations and produces high quality carbon from dilute CO₂ feedstocks.

This technology is an appealing solution to convert and store waste CO₂ as valuable carbon nanomaterials, a material in high demand for use in electronics, batteries, and building materials.

See Related Technologies:

[A semi-continuous process for co-production of CO₂-free hydrogen and carbon nanotubes via methane pyrolysis](#)

[Microbial-driven atmospheric CO₂ conversion for large-scale carbon sequestration](#)

Stage of Development: Proof of concept

Applications

- Upcycling waste CO₂
- Sustainability and environmental goals
- Fossil-free, independent carbon material sourcing

Advantages

- Works with a supply of low concentration CO₂
- Produces high-value carbon, such as multiwalled carbon nanotubes (MWCNTs)

Publications

- Grace Callander, Jörg S. Deutzmann, Alfred M. Spormann (2024), [Alkaline hydrogenotrophic Methanogenesis in Methanococcus vannielii at low carbon dioxide concentrations](#), Journal of CO2 Utilization 83, 102788

Patents

- Published Application: [WO2026060037](#)

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