

Helpful microbes inhale carbon dioxide through a porous cylindrical electrode and exude useful chemicals

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Microbes growing on porous cylindrical electrodes suck in CO₂ and turn it into useful chemicals such as acetate and methane. © 2018 Bin Bian

Microbes could become key allies in global efforts to curb carbon emissions and avoid dangerous climate change. A group of microbes called chemolithoautotrophs consume CO₂ through their natural metabolism, spitting out small organic molecules as a byproduct. These microbes could be enlisted to convert industrial CO₂ emissions into valuable chemicals, thanks to a new concept developed by Pascal Saikaly and his team at KAUST.

Chemolithoautotrophs are commonly found in the deep sea, in caves and hydrothermal vents, where conventional energy sources, such as sunlight and organic carbon, are lacking. "The microbes obtain their energy from the oxidation of inorganic compounds, such as hydrogen, iron and sulfur," explains Bin Bian, a Ph.D. student from Saikaly's team. The microbes strip the inorganic compounds of electrons while taking up CO₂ and reducing it to organic products as part of the process.

To harness chemolithoautotroph capabilities for recycling CO₂ emissions into useful chemicals, researchers supply electrons to the microbes in a process called microbial electrosynthesis (MES). Typically, MES reactors have grown chemolithoautotrophs on a submerged flat-sheet cathode and bubbled CO₂ gas into the solution, but this setup has two key limitations, explains Manal Alqahtani, also a Ph.D student in the team. Flat-sheet cathodes are difficult to scale up and CO₂ gas has poor solubility.

The team developed an alternative MES reactor using cathodes made

from stackable, cylindrical porous nickel fibers that Saikaly's group had previously applied to recover water and energy from wastewater. CO₂ is pumped through each cylinder, and electrons flow along it. "Using this architecture, we directly deliver CO₂ gas to chemolithoautotrophs through the pores in the hollow fibers," Alqahtani says. "We provided electrons and CO₂ simultaneously to chemolithoautotrophs on the cathode surface."

In Alqahtani's initial study, methane-producing microbes were able to convert CO₂ to methane with 77 percent efficiency, compared to 3 percent efficiency with a conventional design.

A follow-up study improved performance further by coating the electrodes with carbon nanotubes. These offered a more biocompatible surface for microbial growth, and improved the hollow fibers' CO₂ adsorption capability 11-fold. "Additionally, the nanotubes enhanced the electron transfer from electrode to chemolithoautotrophs," Bin says. In tests using acetate-producing [microbes](#), production of the chemical almost doubled when the nanotube coating was applied.

Alqahtani's ongoing work includes investigating easier approaches to develop porous cylindrical cathodes, while Bian is optimizing CO₂ flow rates and investing renewable MES energy sources, such as solar. Both students acknowledge the valuable contribution made to their studies by Krishna Katuri, a research scientist in Saikaly's lab.

More information: Manal F. Alqahtani et al. Porous Hollow Fiber Nickel Electrodes for Effective Supply and Reduction of Carbon Dioxide to Methane through Microbial Electrosynthesis, *Advanced Functional Materials* (2018). [DOI: 10.1002/adfm.201804860](https://doi.org/10.1002/adfm.201804860)

Bin Bian et al. Porous nickel hollow fiber cathodes coated with CNTs for efficient microbial electrosynthesis of acetate from CO₂ using

Sporomusa ovata, *Journal of Materials Chemistry A* (2018). [DOI: 10.1039/c8ta05322g](https://doi.org/10.1039/c8ta05322g)

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