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Lighting the path to recycling carbon dioxide

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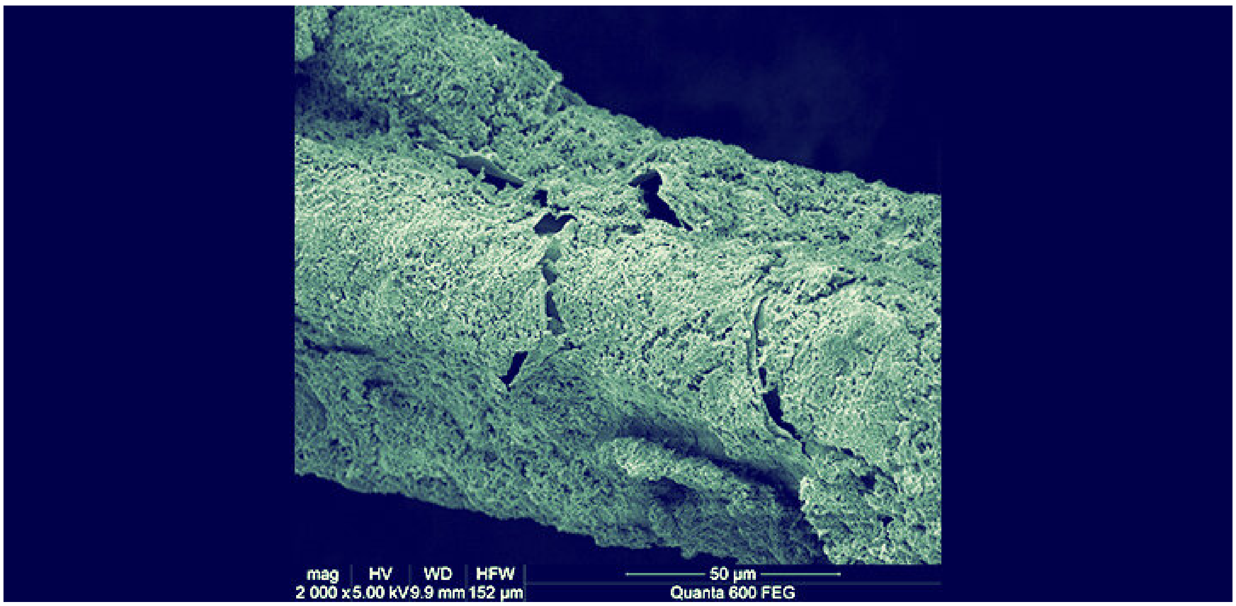

SEM image shows the dense and uniform cathodic biofilm, which mainly comprises chemolithoautotrophs, and could serve as biocatalysts for efficient carbon dioxide conversion to acetate. Credit: 2020 KAUST

Semiconductive photocatalysts that efficiently absorb solar energy could reduce the energy required to drive a bioelectrochemical process that converts CO_2 emissions into valuable chemicals, KAUST researchers have shown.

Recycling CO_2 could simultaneously reduce carbon emissions into the atmosphere while generating useful chemicals and fuels, explains Bin

Bian, a Ph.D. student in Pascal Saikaly's lab, who led the research. "Microbial electrosynthesis (MES), coupled with a renewable energy supply, could be one such technology," Bian says.

MES exploits the capacity of some microbes to take up CO_2 and convert it into chemicals, such as acetate. In nature, chemolithoautotroph microbes metabolize minerals as a source of energy in a process that involves the shuttling of electrons. This capability can be exploited to turn CO_2 into value-added products if the microbes are supplied with a stream of electrons and protons from anodic water splitting in an electrochemical cell (see image).

In their latest work, rather than focus on the CO_2-to-acetate step, the team worked on reducing the energy input for molecular oxygen (O2) production at the anode, a reaction that keeps the overall cell in balance. "In MES systems, the process that consumes the most energy is believed to be the oxygen evolution reaction (OER)," Bian explains. Researchers have used light-capturing anode materials, such as titanium dioxide, that harness energy from sunlight to help drive the OER. In their current work, the team investigated a promising alternative for the photoanode, the light-harvesting material, bismuth vanadate.

Bismuth vanadate absorbed energy from a much broader range of the solar spectrum than titanium dioxide, making the whole MES cell more efficient, the team showed. "We obtained solar-to-acetate conversion efficiency of 1.65 percent, which is the highest reported so far," Saikaly says. "This efficiency is around eight times higher than the 0.2 percent efficiency of global natural photosynthesis, which is nature's solar-powered process for converting CO_2 into energy-rich molecules," Bian notes.

So far the team has kept the microbe biocatalysts supplied with a steady stream of electrons and CO_2 to sustain their growth. "The next step for us is to test our system under real sunlight and monitor the resilience of the biocatalysts under an intermittent renewable energy source," Saikaly says.

More information: Bin Bian et al, Efficient solar-to-acetate conversion from CO2 through microbial electrosynthesis coupled with stable photoanode, *Applied Energy* (2020). DOI: 10.1016/j.apenergy.2020.115684

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