# Microbe power as a green means to hydrogen production

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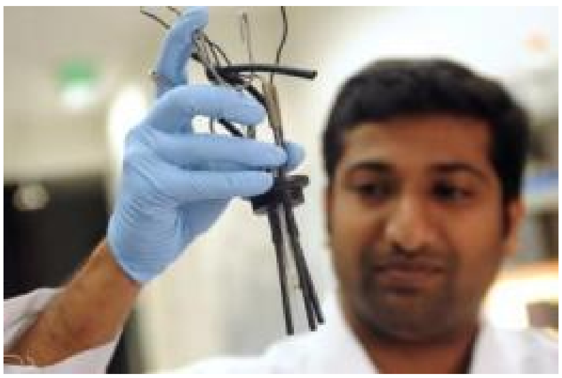


Dr. Prathap Parameswaran showing the electrode used in the microbial electrochemical cell (MEC). When the bacteria are grown in an oxygen-free, or anaerobic environment, they attach to the MXC's anode, forming a sticky matrix of sugar and protein. This living matrix, known as the biofilm anode, is a strong conductor. Credit: The Biodesign Institute at Arizona State University

Scientists have been hard at work harnessing the power of microbes as an attractive source of clean energy. Now, Biodesign Institute at Arizona State University researcher Dr. Prathap Parameswaran and his colleagues have investigated a means for enhancing the efficiency of clean energy production by using specialized bacteria.

Microbial electrochemical cells or MXCs are able to use bacterial respiration as a means of liberating electrons, which can be used to generate current and make clean electricity. With minor reconfiguring such devices can also carry out electrolysis, providing a green path to hydrogen production, reducing reliance on natural gas and other fossil fuels, now used for most hydrogen manufacture.

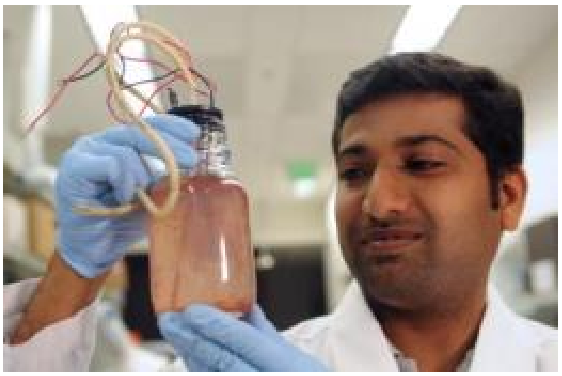
Dr. Prathap Parameswaran showing the electrode used in the microbial electrochemical cell (MEC).

MXCs resemble a battery, with a Mason jar-sized chamber setup for each terminal. The bacteria are grown in the "positive" chamber (called the anode). The research team, led by Bruce Rittmann, director of Biodesign's Center for Environmental Biotechnology, had previously shown that the bacteria are able to live and thrive on the anode electrode, and can use waste materials as food, (the bacteria's dietary staples include pig manure or other farm waste) to grow while transferring electrons onto the electrode to make electricity.

In a microbial electrolysis cell (MEC), like that used in the current study, the electrons produced at the anode join positiviely charged protons in the negative (cathode) chamber to form hydrogen gas. "The reactions that happen at the MEC anode are the same as for a microbial fuel cell which is used to generate electricity, " Parameswaran says. "The final output is different depending on how we operate it."

When the bacteria are grown in an oxygen-free, or anaerobic environment, they attach to the MXC's anode, forming a sticky matrix of sugar and protein. In such environments, when fed with organic compounds, an efficient partnership of bacteria gets established in the biofilm anode, consisting of fermenters, hydrogen scavengers, and anode respiring bacteria (ARB). This living matrix, known as the biofilm anode, is a strong conductor, able to efficiently transfer electrons to the anode where they follow a current gradient across to the cathode side.

The present study demonstrates that the level of electron flow from the anode to the cathode can be improved by selecting for additional bacteria known as homo-acetogens, in the anode chamber. Homo-acetogens capture the electrons from hydrogen in waste material, producing acetate, which is a very favorable electron donor for the anode bacteria.



Microbial electrochemical cells or MXCs are able to use bacterial respiration as a means of liberating electrons, which can be used to generate current and make clean electricity. MXCs resemble a battery, with a Mason jar-sized chamber setup for each terminal. The bacteria are grown in the "positive" chamber (called the anode). Credit: The Biodesign Institute at Arizona State University

The study shows that under favorable conditions, the anode bacteria could convert hydrogen to current more efficiently after forming a mutual relationship or syntrophy with homo-acetogens. The team was also able to reduce the negative impact of other hydogen consuming microbes, such as methane-producing methanogens, which otherwise steal some of the available electrons in the system, thereby reducing current. The selective inhibition of methanogens was accomplished by the adding a chemical called 2-bromoethane sulfonic acid to the adode's microbial stew.

The group used both chemical and genomic methods to confirm the identify of homo-acetogens. In addition to detection of acetate, formate, an intermediary product, was also discovered. With the aid of quantitative PCR analysis, the team was also able to pick up the genomic signature of acetogens in the form of FTHFS, a gene specifically associated with acetogenesis.

"We were able to establish that these homo-acetogens can prevail and form relationships," Parameswaran says. Future research will explore ways to sustain syntrophic relations between homo-acetogens and anode bacteria, in the absence of the chemical inhibitors.

Further progress could pave the way for eventual large-scale commercialization of systems to simultaneously treat wastewater and generate clean energy. "One of the biggest limitations right now is our lack of knowledge," says Cesar Torres, one of the current study's co-authors, who stresses that there remains much to understand about the interactions of bacterial communities within MXCs.

The field is still very young, Torres points out, noting that work on MXCs only began about 8 years ago. "I think over the next 5-10 years the community will bring a lot of information that will be really helpful and that will lead us to good applications."

**More information:** The team's results appear in the advanced online issue of the journal *Bioresource Technology*.

Provided by Arizona State University