PENNSTATE

College of Engineering

Microbial Fuel Cells Q&A

www.engr.psu.edu/ce/ENVE/logan.htm

How do microbial fuel cells (MFCs) work?

Bacteria need energy to survive, in the same way that humans need food to live. Bacteria get this energy in a two-step process. The first step requires the removal of electrons from some source of organic matter (oxidation), and the second step consists of giving those electrons to something that will accept them (reduction), such as oxygen or nitrate. If certain bacteria are grown under anaerobic conditions (without the presence of oxygen), they can transfer electrons to a carbon electrode (anode). The electrons then move across a wire under a load (resistor) to the cathode where they combine with protons and oxygen to form water. When these electrons flow from the anode to the cathode, they generate the current and voltage to make electricity.

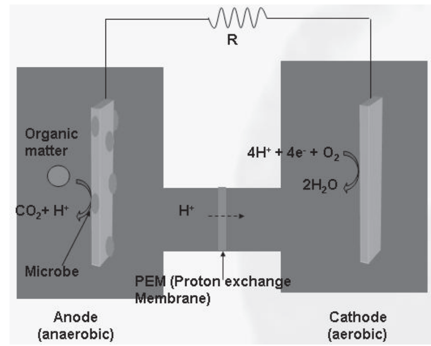

Figure 1. Microbes remove the electrons from organic matter and transfer them to the anode in the anaerobic chamber. The electrons move across the resistor to the cathode where they combine with protons, and oxygen to form water. (Figure courtesy of Jung Rae Kim)

How long have researchers known about MFCs?

Scientists have long known about the connection among chemistry, biology, and electricity. In the late 1700s, Luigi Galvani, an Italian anatomist, noted that a detached frog's leg twitched due to the electrical charges in the atmosphere. His findings helped create the field of electrochemistry. In 1911, scientists in England published one of the first papers on electricity generation by bacteria. Today MFCs are receiving more attention because they are a potential part of the solution to our energy demands and could provide a clean and renewable source of energy.

What kinds of stuff can be used in MFCs in order to generate electricity?

Almost any biodegradable organic matter can be used. Examples include human, animal, and industrial wastewater, along with sugars, starch, and cellulose. Light is even a potential source of "matter" in photobiological fuel cell systems that utilize photosynthetic bacteria, amino acids, and proteins.

What is the maximum power output achieved thus far?

In the Penn State lab using a batch mode (repeated cycles of liquid replacement) MFC, we have achieved up to 1.5 watts per meter squared of electrode surface area. Using a continuous flow MFC, we have recorded values around 15.5 watts per cubic meter of household wastewater flowing through it.

How much power could a MFC theoretically produce today if installed at a wastewater treatment plant?

Our lab estimates that a wastewater treatment plant serving 100,000 people or a large industrial plant could produce around 0.8 megawatts, which is enough to power about 500 homes.

How can MFCs aid in wastewater treatment?

Our results using wastewater indicate that MFCs can remove organic matter to a comparable extent that which is achieved by current wastewater treatment plants.

How much does it cost to treat wastewater?

In the U.S. alone, the cost of treating 33 billion gallons of wastewater is around $25 billion a year. In the future, MFCs will be able to help reduce those costs by producing electricity on site to power the plant's operating equipment.

Can MFCs work in marine environments?

Yes. MFCs can work in marine settings when the anode is buried in anaerobic marine sediments (such as the mud at the bottom of an ocean) and the cathode is installed above the sediment in the oxygen rich water. These types of MFCs can produce enough electricity to power ocean monitoring devices.

How soon before I see an MFC at my local wastewater treatment plant?

It is hard to say right now when MFCs will be implemented on a large scale at treatment plants. Since MFCs are a relatively new technology, the time required to fully develop them depends on the level of investment and quality of research.