Microbial fuel cells turn on the juice

December 5 2007

The combination of beer, wastewater, microbes, fuel cells, high school students and teachers sounds like a witches' brew for an old –fashioned, illicit '60s beach party.

Instead, these are the components that comprise the heart and soul of a new high school science curriculum being developed by researchers at Washington University in St. Louis and a couple of St. Louis area high school teachers.

Lars Angenent, Ph.D., assistant professor of energy, environmental & chemical engineering, has received a $400,000 Career grant from the National Science Foundation to develop microbial fuel cell (MFC) kits and an accompanying booklet of physics, chemistry and biology lessons that pertain to the kit and eventually make them available to high school science teachers everywhere, as an exciting, visual, hands-on way to teach science. As part of the grant, he will be working with Victoria L. May, assistant dean for science outreach in Arts & Sciences and director of the University's Science Outreach program.

Using MFC technology, Angenent is treating wastewater donated by local brewery Anheuser-Busch and in so doing creating electricity in a six-liter device a bit bigger than a large thermos. He uses a mixed medium containing thousands of organisms and optimizes environmental conditions to select for a bacterial community with improved electron transfer in anode biofilms, thereby increasing the electron transfer rate. In addition, he plans to work with a single-culture biofilm to allow a full understanding of how to use operating conditions to manipulate electron

transfer in anode chambers.

“Anheuser-Busch is supporting us not with money, but with wastewater, of which they have an ample supply,” said Angenent. “They’re very happy to be working with us because they have a keen interest in biofuels and bioenergy.

“As a teaching tool, the MFC can enable the teaching of physics, chemistry and biology, all the while making the science exciting. Students will actually be able to see the electricity their MFC is creating. If their MFC is being fed bacteria and sugars correctly, it will turn a light-emitting diode on. Imagine the excitement of that.”

Angenent said that MFC technology offers advantages for converting waste to energy because the microbial fuel cells can operate using the dilute organic waste streams typical of domestic wastewater treatment plants and at low operating temperatures.

Angenent uses a carbon-based fiber on which biofilm grows, allowing him to connect two electrodes in the anode and cathode chambers with a conductive wire.

In a hydrogen fuel cell, a membrane separates the anode and cathode chambers. When hydrogen meets the anode electrode, it splits into protons and electrons, with protons going across the membrane to the cathode chamber, and electrons passing over the wire between electrodes to create a current.

Oxygen is added to the cathode chamber, and on the electrode there is a reaction of electron plus proton plus oxygen to form water. Catalysts, such as platinum, are needed on both electrodes to promote the reactions.

"We are doing basically the same thing as is done in a hydrogen fuel cell with our microbial fuel cell," Angenent said.

"We've found that the bacteria on the anode electrode can act as the catalyst instead of platinum."

With the Career grant funding Angenent intends to advance the conversion to electricity by predicting the power output of various configurations of microbial fuel cells, by ascertaining the selection process for the microbial community in the cathode, thereby enhancing the electron flow, and by understanding how operating conditions can affect the biofilm at the anode.

The research will be integrated with an educational component that will engage students from the Hazelwood school district and encourage them to consider careers in science and engineering.

The educational component will include development of two new courses. One will be in bioprocess engineering for undergraduate and graduate students and will focus on how to transform waste into useful products. The second will be a molecular biology techniques laboratory class.

In addition to development of the two new courses, a program that engages high school students in the science and engineering of microbial fuel cells has been established. Erin Roades and Brett Barron, both chemistry and biology teachers at Hazelwood Central High, are working on the MFC kits, having begun work this past summer on them. They will bring their classes of between 100 and 120 students onto campus once or twice an academic year to teach them using MFC lessons. Over the next two summers, Roades and Barron will compile a curriculum with the MFC as the centerpiece.

The lab classes will be conducted on the university campus providing high school students from underachieving schools to visit and learn about the opportunities in higher education as well as to do hands-on learning, Angenent said. With the experience from the on-campus classes, kits will be developed that will allow extension of the hands-on learning to other high schools.

“We want to make the kits and curriculum available to a larger network beyond our Outreach connections,” Angenent said. “This way a rural school miles away from a university can still use the kits and concepts.”

Source: Washington University in St. Louis