Researchers harness the power of bacteria

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Looking for alternatives to world reliance on fossil fuels for energy, an interdisciplinary team of University of Wisconsin-Madison researchers is studying ways to generate electricity by feeding a species of photosynthetic bacteria a steady diet of sunshine and wastewater.

The concept of such so-called microbial fuel cells emerged nearly three decades ago when an English researcher fed carbohydrates to a bacteria culture, connected electrodes and produced tiny amounts of electricity. Although a few research groups are studying them, microbial fuel cells largely live in the realm of laboratory entertainment and high-school science experiments, says civil and environmental engineering Professor Daniel Noguera. "Now, the idea is taking shape that this could become a real alternative source for energy," he says.

Noguera, civil and environmental engineering Professor Marc Anderson, civil and environmental engineering Assistant Professor Trina McMahon, bacteriology Professor Timothy Donohue, senior scientist Isabel Tejedor-Anderson and graduate students Yun Kyung Cho and Rodolfo Perez hope to develop a large-scale microbial fuel cell system for use in wastewater treatment plants. "It's inexpensive," says Noguera of the nutrient-rich wastewater food source. "We treat the wastewater anyway, so you are using a lot of energy to do that."

In nature, says McMahon, photosynthetic bacteria effectively extract energy from their food — and microbial fuel cells capitalize on that efficiency. "By having the microbes strip the electrons out of the organic waste, and turning that into electricity, then we can make a process of conversion more efficient," she says. "And they're very good at doing that-much better than we are with our high-tech extraction methods."

Through machinery such as plants, photosynthetic bacteria harvest solar energy. They also make products to power microbial fuel cells. "In many ways, this is the best of both worlds — generating electricity from a 'free' energy source like sunlight and removing wastes at the same time," says Donohue. "The trick is to bring ideas from different disciplines to develop biorefineries and fuel cells that take advantage of the capabilities of photosynthetic bacteria."

The benefit of using photosynthetic bacteria, he says, is that solar-powered microbial fuel cells can generate additional electricity when sunlight is available.

Currently, the microbes live in sealed, oxygen-free test tubes configured to resemble an electrical circuit. Known as a microbial fuel cell, this environment tricks the organisms into delivering byproducts of their wastewater dinner — in this case, extra electrons — to an anode, where they travel through a circuit toward a cathode. Protons, another byproduct, pass through an ion-exchange membrane en route to the cathode. There, the electrons and protons react with oxygen to form water.

One microbial fuel cell produces a theoretical maximum of 1.2 volts; however, like a battery, several connected fuel cells could generate enough voltage to be useful power sources. "The challenge is thinking about how to scale this up from the little toys we have in the lab to something that works in the home, on farms, or is as large as a wastewater treatment plant," says Noguera.

For now, the researchers are combining their expertise in materials science, bacteriology and engineering to optimize fuel cell configuration.

Source: University of Wisconsin-Madison, by Renee Meiller