Marine sediment microbial fuel cells get a nutritional boost

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Discarded crab and lobster shells may be the key to prolonging the life of microbial fuel cells that power sensors beneath the sea, according to a team of Penn State researchers.

To produce energy, microbial fuel cells need organic material for the microbes to consume. However, deep sea sediments can be surprisingly devoid of organic material because living things in the photic zone – the area where light penetrates the water – are continuously recycled and little falls to the ocean floor. An absence of organics limits the lifetime of marine microbial fuel cells.

The researchers include chitin – processed crustacean shells – in a pillow-like anode made of carbon cloth. The anode is placed in the sediment or hung in the water where naturally occurring bacteria can eat the chitin.

"This approach is good for deeper ocean areas or anywhere we want to increase the power of marine microbial fuel cells," says Bruce E. Logan, the Kappe Professor of Environmental Engineering.

Microbial fuel cells work through the action of bacteria which can pass electrons to an anode. The electrons flow from the anode through a wire to the cathode, producing an electric current. In the process, the bacteria consume organic matter in the water or sediment. The Penn State approach uses the bacteria that naturally occur in the oceans and because so many sea creatures produce chitinous shells, many marine bacteria break down chitin.

Marine energy sources are often placed in remote areas to power sensors for such measurements as temperature, pressure, salinity, density, turbidity or particulate content. These sensors could be placed on buoys or used to monitor around offshore drilling platforms and to monitor for pollution or contamination, such as that caused by red tide, in both salt and fresh water. Other small devices can measure sound, light transmittance and conductivity. While the amounts of energy needed for these purposes are small, the locations often necessitate long-term remote operation.

The researchers, who included Logan; Rachel A. Brennan, assistant professor of civil engineering; Tom L. Richard, associate professor of agricultural and biological engineering; and Farzaneh Rezaei, graduate student in agricultural and biological engineering, tested two types of chitin and one type of cellulose.

"We found that cellulose was not as good as chitin," Logan reported in the current issue of Environmental Science and Technology. "The ocean is so used to chitin that there may be more naturally occurring bacteria that eat chitin than those that eat cellulose."

While the team has not tested the marine microbial fuel cell in the ocean sediment, they did create a fuel cell in the laboratory consisting of a glass bottle with the anode embedded in the sediment on the bottom and the carbon paper and platinum cathode suspended in the water. In the ocean, no container is needed, but the anode and cathode must be close enough together so the protons or positive charge can pass through the water to the cathode.

The researchers tested two different sizes of chitin, one finer than the other and found that both increased power production over the same set up without the additional bacterial food supply. However, the finer particles produced almost twice the power as the larger particles, suggesting that the bacteria can more easily consume the smaller particles.

"We can adjust the particle size to control the rate at which chitin is consumed and alter the power output and the fuel cell's longevity," says Logan. "Technically, there is no reason why we cannot put a bigger bag of feed for the anode to supply more food."

Source: Penn State