Scientists to develop bacteria-powered fuel cells

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A diverse team of microbiologists, engineers and geochemists from the University of Southern California and Rice University are joining forces to create bacteria-powered fuel cells that could power spy drones that fit in the palm of a hand.

The Air Force has long been interested in micro-scale air vehicles – some as small as insects – but it has been stymied by the lack of a suitable, compact power source. With $4.4 million from the Department of Defense's Multidisciplinary University Research Initiative, or MURI, the USC and Rice research team hopes to prove its concept valid within five years by producing a self-propelled prototype.

At Rice, geochemist Andreas Lüttge will spearhead the team's efforts to understand how the bacteria Shewanella oneidensis attach to and interact with anode surfaces inside the fuel cell. Anodes are the parts of fuel cells and batteries that gather excess electrons for harvesting. To optimize its design, the team must understand how bacteria transfer electrons to anode surfaces under a variety of conditions.

"There are three primary components in the system: the bacteria, the surface and the solution that the bacteria are digesting," said Lüttge, associate professor of earth science and chemistry. "Any change in one variable will affect the other two, and what we want to do is find out how to tweak each one to optimize the performance of the whole system."

Lüttge's participation in the program grew out of a decade-long collaboration with principal investigator Kenneth Nealson, USC's Wrigley Chair in Environmental Studies and Professor of Earth Sciences and Biological Sciences. Nealson helped pioneer the field of modern geobiology and the investigation of the genetic pathways that some microbes rely upon to maintain their respiratory metabolism in oxygen-poor environments. Shewanella oneidensis, one such bacterium, uses metals instead of oxygen to fully metabolize its food.

"Since this organism is capable of passing electrons directly to solid metal oxides, it is not particularly surprising that it can do the same to the anode of the fuel cell, and since we are already in the business of understanding and optimizing the metal reduction capacity, it seemed a reasonable step to apply the same approaches to understanding current production. What is new here is the incorporation of colleagues in chemistry, geology, engineering, and evolutionary biology to optimize the entire system, not just the bacteria."

In the fuel cell study, Lüttge will use computer models to estimate how the bacteria will behave under different circumstances. Running tests on the computer will save time and money by allowing laboratory experiments to focus on best candidate approaches.

"One of the hallmarks of our approach is the vigorous feedback between our computer models and our laboratory work," said Lüttge. "The computer simulations help us perform better experiments, and the laboratory tests help us design better simulation, and the overall combination saves time and money."

In addition to the computational modeling, Lüttge will contribute his experimental skills in an imaging technique called Vertical Scanning Interferometry. The technique, which he helped create in the 1990s, combines information from multiple beams of light to resolve sample features as small as one-billionth of a meter. In previous studies with Nealson, Lüttge used the technique to examine how the cigar-shaped Shewanella attach themselves to crystalline surfaces. The researchers found that Shewanella would lay flat and orient themselves relative to minute defects in the crystal's surface.

"We still have a lot to learn about the chemical cues that the Shewanella use – both individually and in colonies – but they are incredibly efficient at converting organic inputs to electricity, so we are confident that they'll be a great candidate for our fuel cells," Lüttge said.

Source: Rice University

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