Progress Toward a Biological Fuel Cell?

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(PhysOrg.com) -- Biological fuel cells use enzymes or whole microorganisms as biocatalysts for the direct conversion of chemical energy to electrical energy. One type of microbial fuel cell uses anodes (positive electrodes) coated with a bacterial film. The fuel consists of a substrate that the bacteria can break down. The electrons released in this process must be transferred to the anode in order to be drawn off as current. But how can the electrons be efficiently conducted from the microbial metabolism that occurs inside a cell to the anode?

Discoveries made by Japanese researchers regarding the electron-transfer mechanism of Shewanella loihica PV-4 suggest an intriguing approach. As reported in the journal *Angewandte Chemie*, in the presence of iron(III) oxide nanoparticles, these metal-reducing bacteria aggregate into an electrically conducting network.

To meet its energy requirements, our bodies metabolize energy-rich substances. A critical step in this process is the transfer of electrons to oxygen, which enters our bodies when we breathe. Instead of breathing, metal-reducing bacteria that live in subterranean sediments transfer electrons to the iron oxide minerals on which they dwell as the last step of their metabolism. In this process, trivalent iron ions are reduced to divalent ions.

A team led by Kazuhito Hashimoto has investigated how this transfer is carried out in Shewanella loihica. They added the cells to a solution containing very finely divided nanoscopic iron(III) oxide particles and poured the solution into a chamber containing electrodes. A layer of bacteria and iron oxide particles was rapidly deposited onto the indium tin oxide electrodes at the bottom of the chamber. When the cells were "fed" lactate, a current was detected. Electrons from the metabolism of the lactate are thus transferred from the bacteria to the electrode.

Scanning electron microscope images show a thick layer of cells and nanoparticles on the electrode; the surfaces of the cells are completely coated with iron oxide particles. The researchers were able to show that the semiconducting properties of the iron oxide nanoparticles, which are linked to each other by the cells, contribute to the surprisingly high current. The cells act as an electrical connection between the individual iron oxide particles. Cytochromes, enzymes in the outer cell membrane of these bacteria, transfer electrons between the cells and the iron oxide particles without having to overcome much of an energy barrier. The result is a conducting network that even allows cells located far from the electrode to participate in the generation of current.

Paper: Kazuhito Hashimoto, Self-Constructed Electrically Conductive Bacterial Networks, *Angewandte Chemie International Edition* 2009, 48, No. 3, 508-511, doi: 10.1002/anie.200804750

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