New 'biofuel cell' produces electricity from hydrogen in plain air

March 26 2007

A pioneering “biofuel cell” that produces electricity from ordinary air spiked with small amounts of hydrogen offers significant potential as an inexpensive and renewable alternative to the costly platinum-based fuel cells that have dominated discussion about the “hydrogen economy” of the future, British scientists reported here today.

The research was presented at the week-long 233rd national meeting of the American Chemical Society.

Fraser Armstrong, Ph.D., described how his research group at Oxford University built the biofuel cell with hydrogenases — enzymes from naturally occurring bacteria that use or oxidize hydrogen in their metabolism. The cell consists of two electrodes coated with the enzymes placed inside a container of ordinary air with 3 percent added hydrogen.

That is just below the 4 percent danger level at which hydrogen becomes an explosion hazard. The research established for the first time that it is possible to generate electricity from such low levels of hydrogen in air, Armstrong said.

Prototype versions of the cell produced enough electricity to power a wristwatch and other electronic devices. Armstrong foresees advanced versions of the device as potential power sources for an array of other electronic products that only require low amounts of power.

“The technology is immensely developable,” Armstrong said. “We are at the tip of a large iceberg, with important consequences for the future, but there is still much to do before this generation of enzyme-based fuel cells becomes commercially viable. The idea of electricity from hydrogen in air, using an oxygen-tolerant hydrogenase is new, although other scientists have been investigating enzymes as electrocatalysts for years. Most hydrogenases have fragile active sites that are destroyed by even traces of oxygen, but oxygen tolerant hydrogenases have evolved to resist attack."

The biofuel cell has a number of advantages over conventional fuel cells, devices that convert the chemical energy in a fuel into electricity without combustion, Fraser explained. A hydrogen fuel cell uses hydrogen and oxygen, producing water as the only waste product. Platinum is the most commonly used catalyst in conventional (proton exchange membrane) fuel cells, making the devices an expensive alternative energy source with sharply limited uses.

As a precious metal, platinum is in short supply, raising questions about the sustainability of platinum-based fuel cell technology. Platinum is more costly than gold, with recent prices topping $1,000 per ounce. In addition, platinum catalysts are easily poisoned or inactivated by carbon monoxide that often exists as an impurity in industrially produced hydrogen. Carbon monoxide can be removed, but that further increases the cost of conventional fuel cells.

Armstrong pointed out that naturally occurring hydrogenase enzymes can be produced at lower cost, with carbon-monoxide poisoning not being a problem. Since the hydrogenases are chemically selective and tolerant, they work in mixtures of hydrogen and oxygen, avoiding the need for expensive fuel-separation membranes required in other types of fuel cells. Hydrogenases also work at about the same rate as platinum-based catalysts.

The biofuel cell uses enzymes from Ralstonia metallidurans (R. metallidurans), an ancient bacterium believed to have been one of the first forms of life on Earth. It evolved 2.5 billion years ago, when there was no oxygen in Earth's atmosphere, and survived by metabolizing hydrogen.

One focus of Armstrong's research is understanding how the active site of the R. metallidurans hydrogenase developed the ability to cope with oxygen as Earth's atmosphere changed. That could enable scientists to adapt the chemistry in the active site — the working end of the enzyme — into biofuel cells that are more tolerant of oxygen. In the current version of the cell, the enzyme is not attached tightly to the electrode and the cell runs for only about two days. The researchers also are investigating the use of enzymes from other organisms.

Source: American Chemical Society

Citation: New 'biofuel cell' produces electricity from hydrogen in plain air (2007, March 26) retrieved 28 April 2024 from
https://phys.org/news/2007-03-biofuel-cell-electricity-hydrogen-plain.html