Miniaturisation of Fuel Cells Improves Prospects of Technology Commercialisation

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To create a compelling microfuel cell technology, scientists have to look at providing power densities that are comparable to that of conventional or rechargeable batteries. Direct methanol fuel cell (DMFC), a popular fuel cell technology, only provides power density in the range of 20 to 50 mille watts per square cm (mW/cm^2).

DMFCs will have to reach 100 mW/cm^2 to avoid an output density shortfall and to meet the requirements of power-hungry devices such as notebook computers, handheld data collection devices and military equipment.

A DMFC needs a pump and pipes to carry out electrochemical processes. This creates space constraints and it becomes difficult to mount the system on a miniature scale.

A very effective alternative to DFMC is the direct formic acid fuel cell (DFAFC) technology, with five to six times higher power densities. Such high densities aid the miniaturisation of the fuel cells, especially in portable devices. They also improve the efficiency of the fuel cell without compromising on the net output of electricity.

“The use of formic acid as a fuel offers advantages such as less fuel cross-over, use of higher fuel concentrations (80 per cent by weight) at the anode side, good anode kinetics at room temperatures and high power densities,” says Frost & Sullivan Research Analyst Viswanathan Krishnan.

Researchers from Kongkuin University, Japan have worked and improved upon direct borohydride fuel cells (DBFCs) to eliminate or reduce glitches such as borohydride crossover by using a Nafion membrane electrolyte-based fuel cell. They claim to have achieved a power density of 160mW/cm^2 at an operating temperature of 70 degree centigrade.

Taking this further, researchers at the Solid State and Structural Chemistry Unit of Indian Institute of Science, India have proposed a DBFC using hydrogen peroxide as the oxidant. The research team reports power density of 350mW/cm^2 at a cell voltage of 1.2 V.

To generate this electricity, it is important to have catalysts to speed up the electrochemical process. Currently, only platinum and ruthenium are used in the fuel cells as catalysts. Scientists have been working on finding non-noble substitutes that are more cost-efficient for fuel cell technology.

“Scientists are considering nanomaterials as catalysts for fuel cells consisting of carbon-supported metal particles,” notes Krishnan. “The nanomaterial structure increases the surface-to-volume ratio of expensive noble metals and plays a vital role in reducing the overall cost of the fuel cell.”

At the University of Oxford, researchers have suggested using an enzyme catalyst within a fuel cell. Instead of the regular platinum-coated anode, they have used hydrogenase-coated electrode to catalyse efficient oxidation of hydrogen. The cathode contains the fungal enzyme laccase, which catalyses reduction of oxygen to water.

Microfuel cells have been taking giant strides in technology development. Newer designs that give them greater power and efficiency have firmly placed them on the path to commercialisation.