Chemical Engineer Discovers Way of Increasing Battery Life with Environmentally Friendly Fuel Cells

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A Drexel University chemical engineering professor Yossef Elabd is exploring a way to increase battery life with an environmentally friendly alternative. Consumer demands are requiring lithium-ion batteries currently used to power devices such as cell phones and laptops to increase their efficiency and reduce environmental impact.

A possible replacement for lithium-ion batteries, and a solution for the current demand in power density, is fuel cells. These fuel cells use liquid as a source of protons and electrons. They could take the form of an ink cartridge the size of AA batteries made of bio-degradable materials and last more than twice as long as lithium-ion batteries.

Operating at 20 percent capacity, fuel cells provide double the power density of lithium-ion batteries. Fuel cells convert fuel and air directly to electricity, heat and water in an electrochemical process. Elabd and his team are studying the process with which the direct methanol fuel cell operates to increase its power density, which if increased to operate at 100 percent capacity, will provide 10 times more power than the lithium-ion battery.

“Fuel cells are attractive because they provide an innovative alternative to current power sources, with higher efficiencies, renewable fuels and a lower environmental cost,” said Elabd. He is interested in the direct methanol fuel cell (DMFC), which has the potential to fuel portable devices at a much higher power density than the lithium-ion batteries. The DMFC is an attractive fuel cell because it is similar to a battery and can be instantly recharged, according to Elabd. Although there are several different types of fuel cells, the DMFC offers the most promising alternative for portable power applications, because it is a low-temperature device, environmentally benign and its fuel is portable and inexpensive, said Elabd.

The major problem with the fuel cells power density lies in the polymer electrolyte membrane (PEM) for transporting protons from methanol on the anode side to the cathode. The most often used PEM material Nafion®, manufactured since decades ago from DuPont, is problematic. Nafion® absorbs too much of the methanol during the crossover reducing the output voltage and the cell's lifetime.

Elabd and Drexel graduate student Daniel Hallinan Jr. are evaluating this process to determine how the chemicals react and transport with one another. Gravimetric and electrochemical techniques have been used to evaluate this process in the past with little insight., Elabd and Hallinan are now using time-resolved Fourier transform infrared attenuated total reflectance (FTIR-ATR) spectroscopy to determine the diffusion and sorption of both methanol and water in Nafion®, where they have discovered new insights into this process. According to the researchers, this is the first time both multi-component diffusion and sorption were measured in Nafion in the presence of a concentration gradient.

From this study, Elabd and Hallinan concluded that the sorption of methanol rather than its rate has the most impact on the methanol crossover. This should be taken into consideration when developing Nafion® alternatives for methanol fuel cells, according to the researchers. Their findings were published in the 2007, Nov. 22 issue of *Journal of Physical Chemistry B*.

Based on these new insights, Elabd and his team have experimental results that show several new PEMs exhibit lower methanol crossover at similar proton conductivities and higher DMFC power densities. Specifically, their laboratory has demonstrated new PEMs with 30% higher fuel cell efficiencies. These findings were published in the 2006, Dec. 7 issue of Journal of Power Sources.

In the future, Elabd also plans to research the feasibility of applying an electric potential to Nafion® during the time-resolved FTIR-ATR spectroscopy experiment to gain further insights into this process.

Source: Drexel University

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