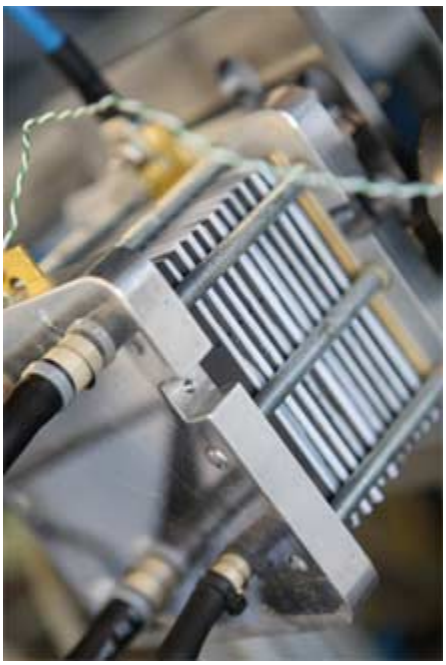
A Liquid Design for Cheaper Fuel Cells

A platinum-free liquid cathode could cut fuel-cell costs by 40 percent.

By Prachi Patel Thursday, September 03, 2009

Platinum remains the best material for speeding chemical reactions in hydrogen fuel cells, although the scarcity and cost of this element keep fuel cells from becoming more affordable and practical. Most alternative approaches involve simply replacing the platinum in the electrodes. Now a U.K. company called ACAL Energy has overhauled fuel cell design to reduce the amount of platinum used by 80 percent.



Liquid design: Inside ACAL Energy's fuel-cell stacks, the cathode is replaced with a platinum-free catalyst solution, which could reduce costs by 40 percent.
Credit: ACAL Energy

In a conventional fuel cell, platinum is embedded in porous carbon electrodes. ACAL's design replaces this with a solution containing low-cost molybdenum and vanadium as the catalyst. The resulting fuel cell works as well as a conventional one but should cost 40 percent less, the company says.

ACAL says its design gives power densities of 600 milliwatts per square centimeter at 0.6 volts. The benchmark value for automotive fuel cells is 900 milliwatts per square centimeter, says Hubert Gasteiger, a visiting professor of mechanical engineering at MIT. ACAL also claims that its fuel cell works unpressurized--adding pressure should increase the power density further.

The new system's power density could reach 1.5 watts per square centimeter, says Andrew Creeth, ACAL's co-founder and chief technology officer. "We believe that we're getting close to a marketable product," he says.

The company has already made a one-kilowatt system that it intends to sell to select customers next year, and the fuel cells should be available more widely in 2011. The plan is to first target the market for diesel generators with one- to 10-kW systems, then move on to larger applications such as home power generation and electric cars.

The platinum in a polymer membrane fuel cell--the top choice for generators and electric cars--splits hydrogen into ions and electrons at the anode, and helps these combine with oxygen at the cathode to form water. But platinum is in limited supply, costing $1,200 per ounce on average over the past three years. And the price is "likely to skyrocket if platinum became heavily used in fuel cells," adds Douglas MacFarlane, a chemistry professor at Monash University in Melbourne, Australia, who is also developing alternative fuel-cell catalysts.

Today's fuel cells use 0.5 grams of platinum for each kilowatt of power they generate, Gasteiger says, but the long-term goal is to use less than 0.2 grams of platinum for each kilowatt.

Many research groups are in the race to make fuel cells that use little or no platinum--substituting platinum with a low-cost metal is the most common approach. Iron-based catalysts and platinum-palladium mixtures have both been tested, and MacFarlane has made porous electrodes coated with polymers. Others, such as Japan's Daihatsu and researchers at Wuhan University in China, are making alkaline fuel cells that have membranes that conduct alkaline ions as opposed to acid ones. These designs work well with cheap catalysts like nickel and don't require precious-metal catalysts. But all of these platinum alternatives have drawbacks: typically they give low current densities or their performance degrades after a few hundred hours.

ACAL Energy's catalyst is based on a low-cost mix of molybdenum and vanadium, and the fuel cell's polymer membrane is in direct contact with this liquid cathode. Around 80 percent of the platinum used in a conventional cell is found in the cathode, all of which is eliminated in the new design.

Creeth says the new catalyst is stable and can withstand the acidic conditions in the fuel cell. In company tests, the fuel cells performed well for more than 1,500 hours. The design has other advantages that decrease cost, he says. While conventional fuel-cell stacks need to be cooled with flowing liquid or air, and they also need a system to humidify the membrane, the liquid catalyst eliminates the need for both of these. "We believe ours is the best-performing platinum-free system," Creeth says.