New Propane-Burning Fuel Cell Could Energize a Future Generation of Small Electrical Devices

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Engineers have created a propane-burning fuel cell that's almost as small as a watch battery, yet many times higher in power density. Led by Sossina Haile of the California Institute of Technology, the team reports in the June 9 issue of the journal *Nature* that two of the cells have sufficient power to drive an MP3 player. If commercialized, such a fuel cell would have the advantage of driving the MP3 player for far longer than the best lithium batteries available.

According to Haile, who is an associate professor of materials science and of chemical engineering at Caltech, the new technology was made possible by a couple of key breakthroughs in fuel-cell technology. Chief among these was a novel method of getting the fuel cell to generate enough internal heat to keep itself hot, a requirement for producing power.

"Fuel cells have been done on larger scales with hydrocarbon fuels, but small fuel cells are challenging because it's hard to keep them at the high temperatures required to get the hydrocarbon fuels to react," Haile says. "In a small device, the surface-to-volume ratio is large, and because heat is lost through the surface that is generated in the volume, you have to use a lot of insulation to keep the cell hot. Adding insulation takes away the size advantage."

The new technology tackles this problem by burning just a bit of the fuel

to generate heat to maintain the fuel cell temperature. The device could probably use a variety of hydrocarbon fuels, but propane is just about perfect because it is easily compressible into a liquid and because it instantly becomes a vapor when it is released. That's exactly what makes it ideal for your backyard barbecue grill.

"Actually, there are three advances that make the technology possible," Haile says. "The first is to make the fuel cells operate with high power outputs at lower temperatures than conventional hydrocarbon-burning fuel cells. The second is to use a single-chamber fuel cell that has only one inlet for premixed oxygen and fuel and a single outlet for exhaust, which makes for a very simple and compact fuel cell system. These advances were achieved here at Caltech."

"The third involves catalysts developed at Northwestern University that cause sufficient heat release to sustain the temperature of the fuel cell." In addition, a linear counter-flow heat exchanger makes sure that the hot gases exiting from the fuel cell transfer their heat to the incoming cold inlet gases.

Although the technology is still experimental, Haile says that future collaborations with design experts should tremendously improve the fuel efficiency. In particular, she and her colleagues are working with David Goodwin, a professor of mechanical engineering and applied physics at Caltech, on design improvements. One such improvement will be to incorporate compact "Swiss roll" heat exchangers, produced by collaborator Paul Ronney at USC.

As for applications, Haile says that the sky is literally the limit. Potential applications could include the tiny flying robots in which the defense funding agency DARPA has shown so much interest in recent years. For everyday uses, the fuel cells could also provide longer-lasting sources of power for laptop computers, television cameras, and pretty much any

other device in which batteries are too heavy or too short-lived.

In addition to Haile, the other authors are Zongping Shao, a postdoctoral scholar in Haile's lab; Jeongmin Ahn and Paul D. Ronney, both of USC; and Zhongliang Zhan and Scott A. Barnett, both of Northwestern.

Source: Caltech