Cheap Hydrogen from Scraps

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Turning organic waste into hydrogen now works without expensive platinum.
By Nora Schultz

It sounds almost too good to be true: add a few bugs to food scraps and waste water to generate clean hydrogen fuel. But over the past few years, researchers have been gradually working toward this promising scheme for producing hydrogen.

Now, with the help of an unassuming stainless-steel brush, microbial electrolysis cells (MECs) have taken another step forward. The steel brush can be used to replace the expensive platinum normally employed in the electrolysis cell's cathode, slashing costs by more than 80 percent.

Hydrogen is an appealing, environmentally friendly fuel because burning it creates only water as a waste product. MECs harness the electrons produced by certain bacteria as those bacteria feed on biodegradable material. The bacteria sit on an electrode—the anode—as they metabolize organic matter in an oxygen-devoid chamber. Not being able to react with oxygen, the electrons travel from the anode to the counter-electrode—the cathode—where they combine with protons to form hydrogen.

In late 2007, a team led by Bruce Logan, Kappe professor of environmental engineering at Pennsylvania State University, showed that they could improve the efficiency of this process: by adding a small jolt of electricity (0.25 volts) at the cathode. Until now, however, the researchers have relied on a platinum catalyst on the cathode to make the process fast enough.

"The need to use a precious metal catalyst had been holding back further development of the technique, but now we have found a way to do it without platinum," says Logan.

Compared with platinum, which acts as an effective catalyst when applied in a thin layer to a flat piece of carbon cloth, a simple piece of stainless steel is two-thirds less effective. But when Logan's team increased the surface area of the stainless-steel cathode by arranging the material in the form of a high-density bristle brush, hydrogen production rates increased to values that matched or even exceeded those of the platinum cathode. While the platinum cathode costs around 15 cents, the stainless-steel brush only set the researchers back 3 cents.

Logan hopes that further modifying the chemistry of the brush will improve the results even more. "We now already know more about which types of stainless steel work best," he says. "And we will also want to minimize hydrogen bubbles being trapped between the bristles because this can make recovery of the gas less efficient."

He also emphasizes that high surface area is not everything. A brush made from carbon with an even higher surface area did 14 times worse than the naked steel-brush core,
and when the researchers cut the steel brush in half to allow closer spacing of the two electrodes, they got even better results than with the full brush, even though they lost half of the surface area.

Lars Angenent (http://angenent.bee.cornell.edu/DrLarsAngenent.html), an associate professor of biological and environmental engineering at Cornell University, says that big challenges remain, and he argues that the effect of electrode spacing is going to be one of the biggest limitations of MEC technology. "I think this work is great, but the next question is, can you scale it up so it's economical?" he says. "In a larger system, moving ions through liquid between cathode and anode is more difficult, so you will produce less hydrogen per unit volume."

Patrick Hallenbeck (http://www.microim.umontreal.ca/asp/Recherche/Profs.asp?ID=73), a professor of bacteriology at the University of Montreal, in Canada, agrees with Angenent that scaling will be a challenge. However, he is optimistic that with the platinum limitation gone, the outlook for MECs is good: "By showing that platinum can be effectively replaced by stainless steel, Logan's group have removed a critical barrier. These devices were first described only four years ago, and there has been tremendous progress since then. Further developments may very well move MEC devices into the realm of practical application."

Upcoming Events

**How Digital Wired the 2008 Presidential Elections and is Changing the World of Politics** (http://www.mitx.org/events/1772.cfm)
Boston, MA
Thursday, February 26, 2009
http://www.mitx.org/events/1772.cfm

Cambridge, MA
Friday, March 06, 2009 - Saturday, March 07, 2009
http://www.mitenergyconference.com/

**O'Reilly Emerging Technology Conference** (http://conferences.oreilly.com/etech)
San Jose, CA
Monday, March 09, 2009 - Thursday, March 12, 2009
http://conferences.oreilly.com/etech

Boston, MA
Monday, March 09, 2009 - Wednesday, March 11, 2009
https://alwayson.goingon.com/cart/add/31230

**South By Southwest** (http://www.sxsw.com/interactive)
Austin, Texas
Friday, March 13, 2009 - Tuesday, March 17, 2009
http://www.sxsw.com/interactive

**Web 2.0 Expo San Francisco** (http://www.web2expo.com/sf)
San Francisco, CA
Tuesday, March 31, 2009 - Friday, April 03, 2009
http://www.web2expo.com/sf

MIT Sustainability Summit: The Transition to a Sustainable World
(Cambridge, MA
Friday, April 24, 2009 - Saturday, April 25, 2009
http://sustainabilitysummit.mit.edu

The Front End of Innovation
(Boston, MA
Monday, May 18, 2009 - Wednesday, May 20, 2009
http://www.iirusa.com/feiusa/fei-home.xml

MIT Sloan CIO Symposium: Sustaining CIO Leadership in a Changing Economy
(Cambridge, MA
Wednesday, May 20, 2009
http://www.mitcio.com/

The Second International Conference on Self-Healing Materials
(Chicago, IL
Sunday, June 28, 2009 - Wednesday, July 01, 2009
https://conferences.beckman.uic.edu/ICSHM2009/index.aspx

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