UNIVERSITY PARK, PA - Making hydrogen by microbial electrolysis has come a long way in recent years, but the need to use expensive platinum as catalyst has been hobbling the economics of the process.

In a microbial electrolysis cell (MEC), bacteria break up fermented plant waste to form hydrogen. A couple of years ago, Bruce Logan and his colleagues at Penn State University had already demonstrated that the process, initially devised to make electricity, could be used to make hydrogen from organic starter materials that could "theoretically be sourced from a salad bar," said a Nov. 2007 National Science Foundation release.

By tweaking their design, improving conditions for the bacteria, and adding a small jolt of electricity, they increased the hydrogen yield to a new record for this type of system. "We achieved the highest hydrogen yields ever obtained with this approach from different sources of organic matter, such as yields of 91 percent using vinegar (acetic acid) and 68 percent using cellulose," Logan was quoted in the announcement as saying.

Now, Logan, Kappe professor of environmental engineering, together with graduate student Douglas F. Call and post-doc researcher Matthew D. Merrill, have discovered they can replace the platinum catalyst in the hydrogen-generating process with much less expensive steel brushes without losing efficiency.

Stainless Steel Brushes as Efficient as Platinum

"Stainless steel brush cathodes can produce hydrogen at rates and efficiencies similar to those we have achieved with platinum-catalyzed carbon cloth," Logan was quoted in a U-Penn announcement as saying.

The brushes were made of 304 grade stainless steel, with the bristles wound into a stainless core with an industrial brush manufacturing
machine. The brushes themselves were one inch long and one inch in diameter with a surface area of 48 square inch.

Hydrogen was produced at a rate of $1.7 \pm 0.1 \text{ m}^3 \cdot \text{d}$ (current density of $188 \pm 10 \text{ A/m}^3$) at an applied voltage $0.6 \text{ V}$. The energy efficiency relative to electrical energy input was $221 \pm 8\%$, and the overall energy efficiency, based on both electrical energy and substrate utilization, was $78 \pm 5\%$.

Said the authors in their paper, "High Surface Area Stainless Steel Brushes as Cathodes in Microbial Electrolysis Cells," in the Feb. 11 Web issue of Environmental Science and Technology, "These results demonstrate for the first time that hydrogen production can be achieved at rates comparable to those with precious metal catalysts in MECs without the need for expensive cathodes."

**Traps Hydrogen Bubbles**

One problem that needs to be addressed is the brushes’ "tendency to trap hydrogen bubbles which decreases the active area of the brush," said Logan. Also, the trapped hydrogen remains in the reactor longer and may be lost to microbes that consume hydrogen.

Still, the high surface area of stainless steel brush cathodes in MECs is important in building larger, more economical, reactors because of the reduced cost of the steel catalyst compared to platinum, the authors said. More steel is required than platinum, but at a platinum cost estimated in Logan's paper at $43.000$/kg (and not counting the cost of the carbon cloth, nafion binder and current collector) compared to $4.82$/kg for this grade of steel, makes the steel brush version one-fifth as expensive as the noble metal version. *Contacts: Penn State University, Bruce E. Logan, 814/863-7908, blogan@psu.edu; media office, A'ndrea Elyse Messer, 814/865-9481, aem1@psu.edu.*