Technology News – April 27, 2005

Practical hydrogen from a microbial fuel cell


In earlier MFC research, Logan's group and others have demonstrated that when conventional microbial foodstuffs, such as glucose and acetate, or even organic compounds in wastewater are fed to bacteria, electricity is generated. Only low power outputs have been reported to date, but researchers anticipate that with further design improvements MFCs can generate commercially viable amounts of electricity. Logan's group, however, offers an alternative path—MFCs that directly produce high yields of hydrogen gas.

Before enough hydrogen gas can be generated biologically, researchers must overcome a biochemical energy barrier that limits yield from bacterial metabolism. Hydrogen from bacterial fermentation is limited to 4 molecules of hydrogen per molecule of glucose, with a practical yield of only 2–3 molecules. That is because hydrogen formation from the end products of fermentation—acetate or butyrate—requires slightly more energy than the metabolic system possesses. Alternatively, electricity-generating MFCs can be used to generate hydrogen by breaking down water, but that process requires substantially more power.

In what one of the top researchers in the field, Bruce Rittmann of Arizona State University, calls a "clever experiment", Logan's group found that applying only a small voltage—just over 250 millivolts—to an MFC circuit degraded more than 95% of the acetate, with a concomitant recovery of 90% of the electrons as hydrogen gas in a completely oxygen-free cell. After accounting for the energy spent providing the boost, this electrochemically assisted reactor could net 8–9 molecules of hydrogen per molecule of glucose, which is much closer to the 10–12 molecules of hydrogen that the U.S. Department of Energy claims is required to make the production of "biohydrogen" from corn economically feasible, says Logan.

In theory, these MFCs can use any dissolved organic matter for food. Logan's group has already generated electricity from acetate, butyrate, ethanol, proteins, and even wastewater from pig farms. Logan believes that he can also make hydrogen from these materials. Whether hydrogen or electricity is produced, "our point is that . . .
you don't need purified sugar anymore. . . . You can use wastewater, you can use fermentation end products, you can use almost anything that is biodegradable," says Logan.

Willy Verstraete of Ghent University (Belgium), another well-known MFC researcher, praises Logan's work as "quite novel", but cautions that the "overall economic balance of it at this point is not certain." He adds that the net energy yield will be less than that when just electricity is made, because of the added boost needed to produce hydrogen.

Electricity or hydrogen? "What do we really want as output here?" asks Rittmann. "What do we prefer to have, what's more useful? . . . There isn't a generic answer. . . . What makes this paper good is it shows there are various ways, various outlets, and different combinations."—BARBARA BOOTH

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