Producing Hydrogen from Swine Manure?

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Energy is vital to global prosperity, yet dependence on fossil fuels as our primary energy source contributes to global climate change, environmental degradation, and health problems. In contrast, hydrogen offers tremendous potential as a clean, renewable energy currency because it has the highest energy density of any known fuel and is compatible with electrochemical and combustion processes for energy conversion without producing carbon-based emissions that contribute to environmental pollution and climate change. Many years of scientific and engineering advances have resulted in two major processes to produce hydrogen, i.e., electrolysis of water and thermo-catalytic reformation of hydrogen-rich organic compounds. Currently, most hydrogen gas produced in the United States is obtained using these two processes from natural gas (50%), petroleum-derived napthenes and distillates (30%), and coal (18%), with the remainder from electricity (2%). Unfortunately, the nature of these processes has ultimately defined that they cannot accomplish the dual goals of waste reduction and hydrogen production. Furthermore, these methods require electricity derived from fossil fuel combustion, thus by no means lessening our reliance on and consumption of petroleum-based energy sources.

In the last decade, hydrogen production through biological processes (e.g., fermentation) is becoming an exciting new area of technology development that attracts increasing interest from researchers around the world. Numerous lab-scale studies in the last few years have revealed that biologically producing usable hydrogen from a variety of renewable resources through fermentation is technically feasible and the possibility of promoting this technology for large-scale production is not beyond reach. Although many agricultural and industrial waste materials or residues have been studied as feedstock, the topic of using liquid swine manure for microbial production of hydrogen has rarely been touched until most recently when a grant was approved

in 2005 by the University of Minnesota Initiative for Renewable Energy and the Environment (IREE) in this area. Currently, lab-scale research is making headway at the UM Southern Research & Outreach Center (SROC) at Waseca, which sets a stage for launching a new and important endeavor on biohydrogen production from an almost inexhaustible renewable source.

In the fermentation process, the fermentative bacteria is capable of generating hydrogen by metabolizing carbohydrates normally contained in wastewaters, such as liquid swine manure. The results obtained so far from the ongoing IREE-funded study at the SROC, in which a continuous batch fermenter is fed with liquid swine manure with about 1-2% total solids content, have shown that levels of as high as 28% in hydrogen concentration in the off gas from the fermenter can be achieved. This information is promising and encouraging, although there is still plenty of room for improvement in product purity. It is not unrealistic to believe that, with further increase in biohydrogen productivity and improved understanding of the process parameters, the emergence of scale-up fermenters for industrial applications is merely a matter of time.

Like any new techniques in the development stage, there are always technical barriers or hurdles that are yet to be overcome before implementation of large-scale biohydrogen production. It has to be acknowledged that scaling up biohydrogen systems for practical application is presenting a great challenge with respect to substrate composition and supply, removal of gas products from the aqueous phase, and hydrogen separation, purification, and storage. Another major roadblock to the utilization of the biologically produced hydrogen lies in the fuel cell technology, with which hydrogen can be converted to electricity for transportation. The current requirement of extremely high purity of hydrogen has demanded rigorous downstream purification before the biohydrogen generated from a fermenter can be fed into the fuel cells. All these obstacles in front of us, although daunting, are not insurmountable. With the joint efforts among engineers and scientists at the University of Minnesota and around the world, the dream of producing hydrogen from swine manure, as well as from other renewable resources, will become reality before long.