Waste to Electricity Via Fuel Cells

Robert J. Remick

Colorado Fuel Cell Center,
Colorado School of Mines, Golden, Colorado, 80401, USA
rremick@mines.edu

1. Introduction

With the increasing costs of natural gas in the USA, the stationary fuel cell community is adopting a new paradigm, operating on methane from anaerobic digesters. The prospect of using a zero or negative value fuel stream has a marked positive impact on overall economics and is very attractive, since commercial rates for natural gas can add 5 to 9 cents per kilowatt-hour to the cost of generating electricity with fuel cells. Both UTC Fuel Cells and FuelCell Energy have had success demonstrating their products on anaerobic digester gas [1,2]. The wastewater treatment facility in King County, Washington State, USA, site of the FuelCell Energy demonstration plant, services a population of about 1.4 million people and produces enough methane to support about 4 megawatts of fuel cell capacity.

In addition to methane produced by anaerobic digestion, there are a significant number of other biomass waste streams that might be adapted for use as a fuel for stationary fuel cells. One of the most promising is waste generated during the production of Biodiesel fuel from soybean oil or palm oil. For every 10 liters of biodiesel fuel produces, about 1 liter of glycerin and higher molecular weight fatty acids is produced as a byproduct. This byproduct waste stream has significant fuel value and could serve, when properly treated, as a fuel for high temperature fuel cells.

2. Key Features

The following comments have been extracted from a technical report on biomass based oils published by the National Renewable Energy Laboratory [3] in June 2004:

- Biomass oils can displace up to 10 billion gallons (220 million barrels) of petroleum (annually in the USA) by 2030
- A crude mixture of glycerin and other impurities is an inevitable byproduct of biodiesel production
- Biodiesel expansion will flood the United States and international markets with glycerin

This last prediction is already a matter of fact. Dow Chemical closed its glycerin plant in Freeport, Texas on January 31, 2006, citing the flood of glycerin from biodiesel production [4]. If the prediction of 10 billion gallons of biodiesel production by 2030 are realized, the amount of byproduct glycerin produced would represent 30 times the current US production. Prices for the crude glycerin could fall as low as $0.05 per pound ($0.12/kg) at which point it could be sold as a boiler fuel [3].

Glycerin has about half the fuel value of an equivalent weight of hydrocarbon oil. However, unlike oil, it is fully miscible in water thus simplifying the mixing of steam and fuel for steam reforming. Rather than having separate fuel evaporation and steam injection systems, a single mixture of glycerin and water can be vaporized.

Tests conducted at the Gas Technology Institute in Des Plaines, Illinois have shown that glycerin/water mixtures can be injected directly into a solid oxide fuel cell operating at 800°C with no observed complications and good electricity production. However, this work only used pure glycerin, not the crude glycerin that is the byproduct of biodiesel production.

3. Conclusions

The curde glycerin that is a byproduct of biodiesel production has the potential to be a viable fuel for high temperature fuel cells. However, work needs to be done to address the issues of using crude byproduct glycerin as a fuel for solid oxide fuel cells. In particular questions about the impact of impurities on fuel vaporization and SOFC operation, fuel stability during vaporization, and the impact of high molecular weight fuels on the internal dynamics of the SOFC anode need to be addressed.

4. References and Bibliography

1. Stahl, K., 2005, "5 Years Operation of a PC25 Fuel Cell on Anaerobic Digester Gas," 2005 Fuel Cell Seminar-Abstracts, November 14-18, 2005, Palm Springs, California, pp 241-244.
2. Bush, G., and Skok, A., 2005, "MW Size Fuel Cell Power is Here," 2005 Fuel Cell Seminar-Abstracts, November 14-18, 2005, Palm Springs, California, pp 264-267.
3. Tyson, K.S., Bozell, J., Wallace, R., Petersen, E., and Moens, L., 2004, "Biomass Oil Analysis: Research Needs and Recommendations," Report No: NREL/TP-510-34796, June, www.nrel.gov/docs/fy04osti/34796.pdf, last accessed September, 2006.
4. McCoy, M., 2006, "Glycerin Surplus," Chemical & Engineering News, February 6, pp. 7.

Acknowledgements

The Colorado Fuel Cell Center (CFCC) was organized in 2005 with funding from the Governor's Office of Energy Management and Conservation and from four partners, the Colorado School of Mines, the Gas Technology Institute, the National Renewable Energy Laboratory, and Versa Power Systems, Inc. The mission of the CFCC is to perform fuel cell related R&D and to assist local fuel cell developers in overcoming technical barriers to commercialization.

The Colorado School of Mines, who is a partner in the Colorado fuel Cell Center, has a unique suite of experimental apparatus suitable for addressing these important issues. Professor Anthony Dean is currently addressing questions of fuel stability and reforming characteristics for a number of heavy hydrocarbon fuels. Professor Robert Kee and Assistant Professor Neal Sullivan are using a one-of-a-kind separated anode apparatus to study the internal reforming characteristics and heterogeneous and gas phase kinetics of the fuel reforming reactions that take place directly on the fuel cell anode. Dr. Kee is also Principal Scientist on a Office of Naval Research sponsored multi-university research initiative, that includes California Institute of Technology and the University of Maryland, to study the fundamental chemistry and physics of direct hydrocarbon oxidation in solid oxide fuel cells.

Author Biography

Dr. Remick is employed as an Institute Scientist with the Gas Technology Institute in Des Plaines, Illinois, and holds rank as a Research Professor at the Colorado School of Mines. Dr. Remick's current assignment is as Executive Director of the Colorado Fuel Cell Center, in Golden, Colorado. Dr. Remick earned a Ph.D. in Inorganic Chemistry from the Pennsylvania State University in 1978 and has 28 years experience working in high temperature fuel cell R&D at GTI and its forerunner organization the Institute of Gas Technology. Dr. Remick has 45 scientific publications and holds 9 US Patents.