Design and Fabrication of a Methanol Reformer for Production of Hydrogen as Fuel for High Temperature Proton Exchange Membrane Fuel Cells

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Proton Exchange Membrane Fuel Cells (PEMFCs) are promising sources of electrical energy for automotive, stationary, back-up power, and portable applications, having the potential to reduce our energy use and the nation’s dependence on imported oil. Fuel cells use hydrogen as fuel and air or pure oxygen as oxidant to produce electricity with water being the only by-product. As identified by the U.S. Department of Energy, one of the most technically challenging barriers to the widespread commercialization of fuel cells is the on-board storage of hydrogen in automotive and portable applications. Although possible to carry it on-board as compressed gas or liquefied form, hydrogen has a low storage density and requires high-cost metal hydride canisters. Due to its low energy density, very large volumes of hydrogen canisters would be required.

Nevertheless, hydrogen can be carried on-board in the form of a liquid fuel such as methanol which has a significantly higher energy density and does not require special technology for storage. Methanol can be reformed to produce hydrogen rich gas at temperatures as low as 250°C-300°C. This temperature range is slightly higher than the operating temperature of some PEMFCs using phosphoric acid-doped polybenzimidazole membrane electrode assemblies. The hydrogen rich gas exiting the reformer may thus be used as fuel as well as a heater for the fuel cell.

The objectives of this research are to design, build and demonstrate a methanol reformer (Figure 1) for 1 kW portable PEMFC systems. The endothermic steam reforming of methanol over Cu/ZnO/Al₂O₃ catalyst requires the reactor to be heated at temperatures between 250°C-300°C. This is achieved with a tube-in-tube type of reactor in which the highly exothermic peroxide decomposition reaction over Pt-based catalyst is used in the inner tube to heat the reactor. The methanol and peroxide solutions are pumped in the reformer using peristaltic pumps controlled by an Arduino Mega controller (Figure 2). The controller also maintains the reactor temperature within the specified values and shuts down the system in case of emergency. The system is equipped with components for safety operation.

The reformer was designed, built and loaded with catalyst. Work that remains to be completed includes the in-situ activation of the Cu-based catalyst for steam reforming, testing the system and performing quantitative measurements of the efflux gas using mass spectrometry. The
A portable fuel cell system equipped with this reformer will be used to power an Unmanned Aerial Vehicle.

References
The Control System for Methanol Reformer