PROPANE FUELED SOLID OXIDE FUEL CELLS

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Propane is interesting as a fuel for portable and remote fuel cell power generation applications because it is widely available, has a high energy density in liquid form, and also has a sufficiently high vapor pressure at ambient temperature to obviate the need for a fuel pump/blower. SOFCs are a logical choice for small-scale generators using propane as a fuel, since they can provide high power density and have good fuel flexibility. The energy densities of liquid propane (46.4MJ/kg, 22.8MJ/l) are considerably larger than for methanol (19.9MJ/kg, 15.8MJ/l), a fuel used in proton-exchange membrane fuel cells (PEMFC). In addition, methanol is normally mixed with water for use in PEMFCs, further reducing the energy density. Thus, propane-fueled SOFC portable generators have a fundamental advantage over direct-methanol PEMFC generators.

In principle, propane can be externally reformed to produce hydrogen-rich fuel for SOFC operation. However, this introduces unwanted additional size, weight, and complexity for small-scale generation applications. It would be more practical to directly introduce propane to the SOFC. Two approaches have been used with propane and a similar fuel, butane. First, single-chamber SOFCs have been reported where a fuel-air mixture is supplied to the cell and internal partial reforming generates hydrogen at the SOFC anode (1). Alternatively, SOFCs with novel anodes, based either on Cu (2) or conducting ceramics (3), have been reported to work with essentially pure propane or butane.

This paper describes recent results on the operation of SOFCs with propane fuel. Two strategies have been employed. First, conventional anode supported SOFCs have been operated with propane-air mixtures. In this case, the cells operate by internal partial oxidation. For propane contents < 11% (oxygen-to-propane molar ratios > 1.7), there was no carbon deposition detected at 800ºC. Power densities as high as 0.6W/cm^2 were obtained at 800ºC. Second, thick $Ce_{0.9}Gd_{0.1}O_{1.95}$ (GDC) electrolyte SOFCs with ceramic-based anodes have been operated with slightly humidified propane without coking and power densities up to 0.14 W/cm^2 at 750ºC. These cells were cycled between propane and air several times without anode degradation.

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