Solid Oxide Fuel Cells Enable Direct Oxidation of Common Liquid Fuels

Fuel cells can produce power in the same way that combustion engines can, but with higher efficiencies and environmentally friendly and predictable by-products. However, a major difficulty in the implementation of fuel cells is the requirement that most fuels must first be converted to hydrogen. Current research in this field focuses on creating materials that electrochemically oxidize and draw power from readily available fuels, such as gasoline and diesel fuel, without first reforming these fuels to hydrogen. To this end, researchers at the University of Pennsylvania, led by Raymond J. Gorte, have revealed that Cu-cermet anodes are capable of electrochemically oxidizing toluene, n-decane, and synthetic diesel fuel directly, without first reforming them to hydrogen.

As reported in the *Journal of The Electrochemical Society* **148** (7) (2001), model solid-oxide fuel cells were used. The fuel cells were prepared by first fabricating an yttria-stabilized zirconia (YSZ) wafer with a 400-μm porous layer and a 60-μm dense layer. After attaching the cathode material (50:50 YSZ and $La_{0.8}Sr_{0.2}MnO_2$) on the dense side of the YSZ wafer, the porous side was made into a composite anode by impregnation with nitrate solutions of Cu and *ceria* and subsequent oxidation and reduction to form the Cu-*ceria*-YSZ cermet. Electrocatalytic characterization was then performed while injecting liquid hydrocarbons (toluene, *n*-decane, and synthetic diesel fuel) directly into the cell. A flow of dry N_2 gas was included in most, but not all, of the experiments to maintain flow. Fuel conversions were less than 1%, conditions that are most likely to cause coking (i.e., the formation of tar-like substances) because insignificant amounts of water are formed. The cathode was left open to air.

Results for Cu-ceria-YSZ cermets showed positive characteristics, according to the researchers. First, the fuel cell was stable. The cell was operated at 973 K and a potential of 0.5 V for 12 h in a 40 wt% hydrocarbon-N_2 mixture for each of the three fuels. The anode was also stable in pure *n*-decane for at least 1.5 h. By comparison, the researchers reported, a fuel cell made with a traditional Ni-based anode was rapidly destroyed at 973 K in the 40% toluene-N_2 mixture. Even without optimization or the use of a thin electrolyte, a reasonable power density of 0.1 W/cm^2 was observed for each of the fuels with a 40 wt% hydrocarbon-N_2 feed. Analysis of the effluent gas using gas chromatography for the toluene feed showed that the fuel was completely oxidized to CO_2 and water.

The researchers said that this report is important to the materials community in the search for cost-effective, environmentally friendly ways to use hydrocarbon fuels to produce electrical power, especially for transportation and portable power devices.

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2D Nanopatterns Observed in Lead Films Indicate Potential for Nanotemplating

Researchers from Sandia National Laboratories in Albuquerque and Livermore have observed two-dimensional nanopatterns, indicating that nanotemplates can be formed to fine-tune device characteristics of self-assembling nanostructures. In the August 30 issue of *Nature*, the researchers show a sequence of low-energy electron microscope images of lead deposited on a Cu(111) substrate followed by a lead overlayer phase. The pattern evolved from circular islands with an average diameter of 67 nm, to stripes, and then to vacancy islands within the lead-overlayer matrix. The researchers account for this sequence due to the high mobility of the islands containing thousands of atoms. The researchers furthermore suggest that the stabilization of domain patterns is a result of the elastic interactions that come from a surface-stress difference

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