

Power Generation from Solid Fuels in Solid Oxide Fuel Cells with a Molten Antimony Anode

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Abstract

In this study we demonstrate the generation of electricity at high power densities, >300 mW/cm^2 at 973 K, from a solid fuel (sugar char) in a Solid Oxide Fuel Cell (SOFC) using a molten Sb anode. The anode design is simple and capable of operating continuously on a wide range of carbonaceous fuels, including sugar, rice starch, carbon black, and graphite. The following reactions take place in the anode of this cell:



The fact that both Sb and Sb_2O_3 are liquids at the cell operating temperature of 973 K give Sb some advantages over other metals such as Sn that have been proposed for this application.

A cell with an Sb anode operating at 973 K exhibited an open-circuit voltage of 0.75 V, which is close to the theoretical Nernst potential for equilibrium between Sb and Sb_2O_3 . A maximum power density of $360 \text{ mW}/\text{cm}^2$ was obtained at a current density of $0.9 \text{ A}/\text{cm}^2$. Fig. 1 shows data for a cell with an anode containing 2 g of Sb both with and without 0.5 g of sugar char added as a carbonaceous fuel. For the pure Sb case, the cell potential began to drop after less than 1 h, corresponding to conversion of only $\sim 10\%$ of the Sb to Sb_2O_3 . Beyond this conversion, the accumulation of Sb_2O_3 increased the cell resistance. In contrast, for the cell with the added carbon fuel, the cell performance was constant for more than 12 h, a time sufficiently long to have oxidized all the Sb twice. This demonstrates that the Sb_2O_3 is being reduced as it is formed, maintaining the performance of the cell. Once the fuel was consumed, the cell performance began to drop. Physical examination of the cell following this experiment showed that all of the fuel had been consumed.

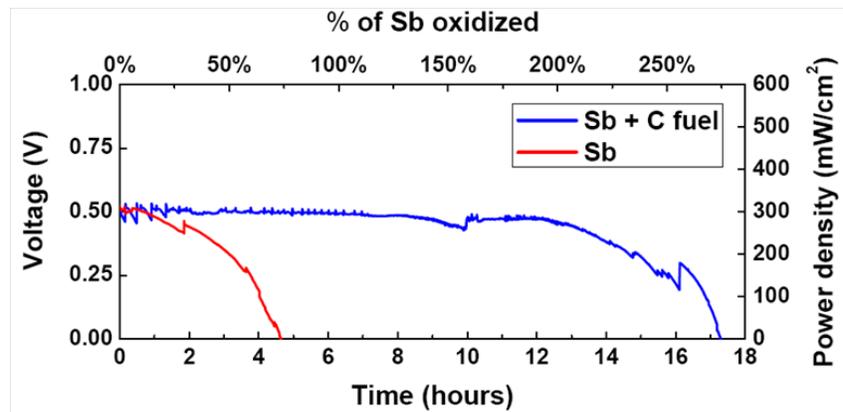


Fig. 1. Performance data for cells with molten Sb anodes with and without sugar char fuel.