

Effect of Coal Syngas Fuel Composition on the Performance and Stability of Oxide Anodes

To cite this article: David M. Bierschenk *et al* 2009 *Meet. Abstr.* **MA2009-02** 1451

View the [article online](#) for updates and enhancements.

You may also like

- [The Performance of Syngas-Fueled SOFCs Predicted by a Reduced Order Model \(ROM\): Temperature and Fuel Composition Effects](#)
Xinfang Jin, Anthony Ku, Atul Verma et al.
- ["Electrofuel" Production Using Ammonia or Iron as Redox Mediators in Reverse Microbial Fuel Cells](#)
Scott Banta, Alan C. West, Kartik Chandran et al.
- [Electrochemical Disinfection of Human Urine for Water-Free and Additive-Free Toilets Using Boron-Doped Diamond Electrode](#)
Akshay S. Raut, Garry B. Cunningham, Charles B. Parker et al.



Your Lab in a Box!

The PAT-Tester-i-16: All you need for Battery Material Testing.

- ✓ All-in-One Solution with integrated Temperature Chamber!
- ✓ Cableless Connection for Battery Test Cells!
- ✓ Fully featured Multichannel Potentiostat / Galvanostat / EIS!

www.el-cell.com +49 40 79012-734 sales@el-cell.com

EL-CELL[®]
electrochemical test equipment



Effect of coal syngas fuel composition on the performance and stability of oxide anodes
 David M. Bierschenk[†], Jacob Haag^{*}, Kenneth R. Poeppelmeier^{*}, Scott A. Barnett[†]
 Department of Materials Science and Engineering[†]
 Department of Chemistry^{*}
 Northwestern University, Evanston IL, 60208, USA

Oxide materials have been widely promoted as potential alternatives to the Ni-cermet solid oxide fuel cell (SOFC) anodes for applications where coking is likely and fuel impurities such as H₂S are present. However, these anodes typically are less active for fuel oxidation than the Ni-cermets. This talk presents a study of two promising new oxide anodes, La_{0.8}Sr_{0.2}Cr_{0.2}Ru_{0.18}O_{3-δ} (LSCrRu)/Gd_{0.1}Ce_{0.9}O₂ (GDC) and LaSr₂Fe₂CrO_{9-δ} (LSCrFe)/GDC. The composite oxides were evaluated for operation on coal syngas compositions that, without significant pretreatment, would coke and poison Ni-based anodes.

The button cells consisted of La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_{3-δ} (LSGM) electrolyte supports and thick film La_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_{3-δ} (LSCF)/GDC cathodes. The maximum observed peak power densities in dry hydrogen at 800°C was 450 mW/cm² and 490 mW/cm² for the LSCrRu/GDC and LSCrFe/GDC based cells respectively. Figure 1 shows typical results. The corresponding anode polarization resistances, measured with electrochemical impedance spectroscopy (EIS), were 0.26 Ωcm² and 0.19 Ωcm² respectively. For all cells, the LSGM electrolyte resistance was dominant, contributing >0.3 Ωcm² to the total resistance. Cells with LSCrFe/GDC and LSCrRu/GDC anodes were operated on a surrogate coal gas fuel blend containing 3% N₂, 17% CO₂, 41% CO, and 39% H₂ (Fig. 1). Stable, coke-free operation was achieved for all cells and conditions (700–800°C) tested except for an LSCrFe/GDC cell operated on dry coal gas at 700°C.

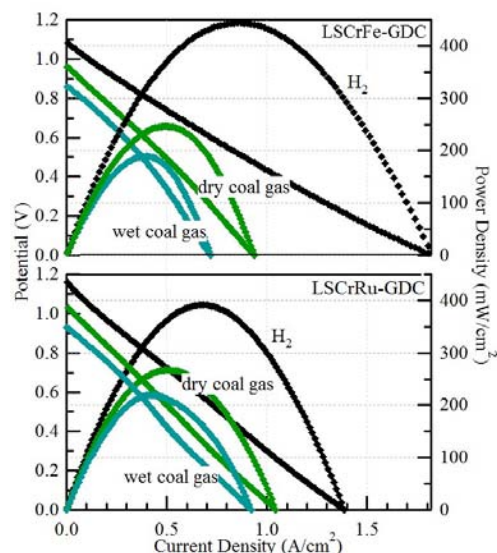


Figure 1. Current-voltage characteristics for an LSCrFe/GDC (top) and LSCrRu/GDC (bottom) cell operated at 800°C.

For both cells, the performance was lower during operation on dry coal gas compared to hydrogen. The addition of 28% steam further decreased cell performance. These losses were attributed to a decrease

in the open circuit potentials (as expected from the fuel's Nernst potentials) and an increase in the anode polarization resistance. The relative performance decrease in the LSCrRu/GDC anode was significantly smaller than in the LSCrFe/GDC anode; the anode polarization resistance measured by EIS increased ~50% for LSCrRu compared to ~150% for LSCrFe upon switching from H₂ to dry coal gas. This difference was attributed to significant activity for the water gas shift (WGS) reaction in the LSCrRu/GDC anode, due primarily to the presence of Ru nano-particles on LSCrRu surfaces.

To better understand these results, the abilities of the anodes to oxidize CO versus H₂ were tested by running cells in CO-H₂ mixtures. The polarization resistance of both anodes increased with increasing CO content (Fig. 2), explaining the increased polarization resistances in coal gas (Fig. 1). The LSCrFe/GDC anode showed superior kinetics for oxidation of pure CO compared to LSCrRu/GDC. While the polarization resistance of the LSCrFe anode increased approximately linearly with CO content, the LSCrRu anode performance loss accelerated at high CO contents. This was explained by the conversion of CO to H₂ by WGS (using electrochemically-produced H₂O), a reaction path available for the LSCrRu/GDC anode in H₂-CO mixtures but not pure CO.

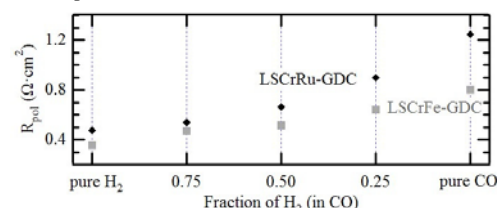


Figure 2. Anode polarization resistance observed for operation on H₂-CO mixtures at 800°C and 600mV.

Cell stability and coking were scrutinized for cells run at 700°C on pure CO, where an LSCrRu/GDC cell was operated without degradation for ~50 h. Postmortem analysis by scanning electron microscopy and energy dispersive x-ray spectroscopy indicated only a trace of carbon on the anode free surface. In contrast, the LSCrFe/GDC cell degraded under these conditions and significant coking was observed on the anode, possibly explained by formation of metallic Fe on LSCrFe at low pO₂ that can catalyze CO disproportionation. A Ni-YSZ supported cell tested at this condition experienced catastrophic coking.

Both anodes were operated on hydrogen laden with H₂S. The LSCrRu/GDC anode degraded upon exposure to low levels (~10ppm) of H₂S. The LSCrFe/GDC anode was stable up to 22ppm H₂S.

Based on the above results, LSCrFe/GDC and LSCrRu/GDC both possess many attributes required for coal syngas utilization. Neither anode showed ideal characteristics for use with coal gas: LSCrRu was susceptible to sulfur poisoning while LSCrFe showed coking under some conditions. An additional concern for these and other oxide anodes is a relative lack of good processing routes to synthesize oxide anodes in thin-electrolyte cells. Thus, a novel process and cell design utilizing an electronically conducting Sr_{0.8}La_{0.2}TiO_{3-δ} support, a porous YSZ anode scaffold, and a thin YSZ electrolyte has been developed. The oxide anodes are introduced via infiltration. Results on the performance of these novel cells will be presented.