

TOWARDS FUEL FLEX SOLID OXIDE FUEL CELLS BY INTERNAL GRADUAL REFORMING

S. D. Nobrega^{1,2}, S. Georges², M. C. Steil², F. C. Fonseca¹

¹Nuclear and Energy Research Institute - IPEN, 05508-000, São Paulo, Brazil

²LEPMI, CNRS-Université de Grenoble, 38400 Saint Martin d'Hères, France
fcfonseca@ipen.br

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Introduction

An interesting approach for running solid oxide fuel cells (SOFCs) with different fuels has been the decoupling of the catalytic and electrochemical reactions taking place in the anode. Such a feature is possible by adding an active layer able to process the fuel and to protect the Ni-based anode. Some previous studies have demonstrated SOFCs running on carbon containing fuels with satisfactory performance and stability by using such a catalytic layer. However, most of those studies add water to the fuel to ensure the stability of the anode.

Otherwise, the gradual internal reforming (GIR) was theoretically and experimentally demonstrated to result in long-term stability of SOFCs operating without added water, as shown in the schematic of Fig. 1.

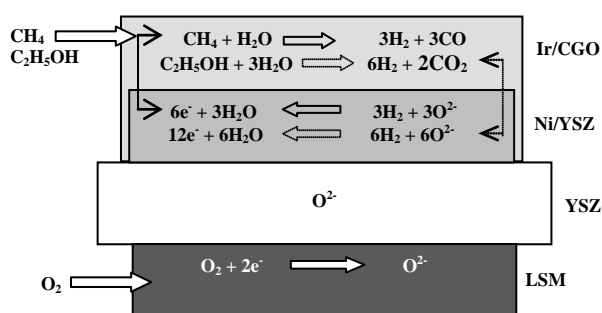


Figure 1. Scheme of gradual internal reforming unit cell and reactions on direct methane and ethanol. The unit cell is comprised of a lanthanum manganite (LSM) cathode, YSZ (yttria-stabilized zirconia) electrolyte, Ni/YSZ anode, and Ir/CGO (gadolinia-doped ceria) catalytic layer.

Thus, provided that an adequate catalyst is available, the GIR opens up the way for the development of fuel-flexible SOFCs. In the present study, an iridium/ceria-gadolinia (Ir/CGO) catalyst was used as the active layer in a SOFC operating in the gradual internal reforming with methane and ethanol.

Experiments

Electrolyte supported single cells were fabricated using the standard yttria-stabilized based components. An additional catalytic layer of gadolinia-doped ceria with 0.1 wt.% of iridium was deposited over the anode. Fuel cell tests were performed at 850°C with flowing synthetic air in the cathode side (5 Lh⁻¹). Fuel cells were initially operated on H₂ (60%) for anode reduction.

After stable OCV = 1.22 V was recorded, the electrochemical properties were studied under hydrogen, ethanol, and methane. Fuels were carried by argon at total flow rate of 4 Lh⁻¹ and no water was added to the fuel. Hydrogen (60%) was interchanged by methane (20%) or ethanol (10%) during continuous fuel cell operation at 0.6 V.

Results and Discussion

The Fig. 2 shows the time dependence of the current density (*i*) using H₂, methane, and ethanol. The operation was initiated in H₂, and after a steady operation (~3 h), the fuel was switched to methane and ethanol, summing up a total of ~400 h of continuous operation.

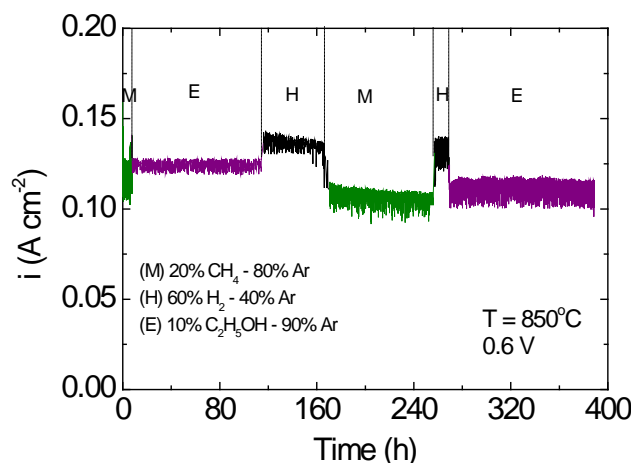


Fig. 2. Potentiostatic test recorded at 0.6 V of a single SOFC containing a ceria-based catalytic layer operating on hydrogen, ethanol, and methane.

Conclusions

A fuel-flexible solid oxide fuel cell was demonstrated to operate on methane, bioethanol, and hydrogen for 400 hours. Stable current outputs in different fuels indicated that the gradual internal reforming was effective, preventing deleterious carbon formation and delivering similar current outputs under different fuels. Based on the present results, the design of both optimized fuel cells and catalyst open the way to the development of high-performance fuel-flexible SOFCs running directly on renewable fuels.

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