

Iso-octane internal reforming in a solid oxide fuel cell using Co/CeO₂ as anodic composites

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Abstract

The global energy demands for sustainable energy are expected to increase in the following years, resulting in an increased interest for electrical vehicles, as the corresponding internal combustion engines are characterized by their low efficiencies and high emissions. However, the transition to electrical vehicles requires the development of a new type of energy storage and conversion systems, such as batteries and fuel cells. Fuel cells can directly convert the chemical energy of H₂ to electrical power with zero environmental footprint (when hydrogen is generated from renewable energy resources) at high efficiencies. The high cost of transporting and storing H₂, as well as its low volumetric energy density, render H₂ vehicles prohibitive for wide use. Diesel and gasoline, on the other hand, have a higher energy density and are easier to handle. Also, in contrast to hydrogen, the necessary production, storage and distribution infrastructure for these liquid fuels already exists. Based on the above, direct, high efficiency diesel or gasoline fed fuel cells seem to be ideal for use in electric vehicles [1].

The steam reforming of liquid hydrocarbons for hydrogen production has been studied, mainly on Ni-based catalysts [2]. These catalysts have been shown to exhibit high catalytic activity and selectivity toward hydrogen, but their stability is dramatically reduced due to the sintering of Ni particles via their interaction with H₂O and to extensive carbon deposition. Recently, the internal steam reforming of iso-octane in a solid oxide fuel cell (SOFC) using a Cu-CeO₂ anode, has been demonstrated. The Cu-CeO₂ composite showed high catalytic activity for hydrogen production, good ionic and electronic conductivity and relatively low carbon deposition [3]. Furthermore, catalytic studies showed that the substitution of Cu by Co improved the catalytic activity and yield toward hydrogen without compromising stability. Thus, in the present work we investigate the performance of a SOFC of the type 20%Co-CeO₂/YSZ/LSM-YSZ that is directly fed with iso-octane, a common surrogate of conventional gasoline.

Initially, the catalytic activity of Co-CeO₂ electrode was studied at open circuit conditions for the iso-octane steam reforming reaction. The products mainly consisted of H₂, CO, CH₄ and CO₂, while a mixture of olefins (C₂H₄, C₃H₆ and C₄H₈) and C₂H₆ were detected in low quantities, possibly originating from iso-octane thermal decomposition.

At temperatures higher than 800°C higher hydrocarbons were not observed, thus demonstrating the excellent catalytic reforming activity of the Co-CeO₂ electrode.

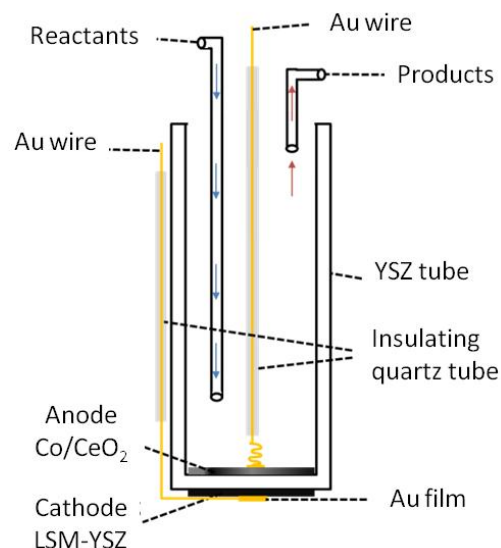


Figure 1. Schematic representation of the fuel cell reactor.

The iso-octane conversion was almost complete at temperatures higher than 800°C. Concerning the mass-balances of carbon, oxygen and hydrogen, deviations higher than 5% were not observed, thus verifying the electrode tolerance toward carbon deposition. Concerning the fuel cell experiments, the obtained power density in the case of stoichiometric i-C₈H₁₈/H₂O feed mixture, was at about 75% of the corresponding achieved power when a mixture of 10%H₂/Ar was fed in the cell.

References

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