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Combustion synthesis of $La_{0.7}Sr_{0.3}Co_{0.5}Fe_{0.5}O_3$ (LSCF) porous materials for application as cathode in IT-SOFC

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ABSTRACT

$La_{0.7}Sr_{0.3}Co_{0.5}Fe_{0.5}O_3$ (LSCF) porous materials have attracted a substantial interest for application as cathode in solid oxide fuel cells of intermediate temperature (IT-SOFC). This work investigates the effect of different propellants (urea, glycine, citric acid and sucrose) in the preparation of LSCF powders by the combustion method and also the influence of the sintering temperature on the porosity and electrical conductivity. TGA profiles of the as-prepared samples showed a lower weight loss for the sample prepared with glycine, associated with the higher combustion temperature. XRD patterns presented characteristic reflections of LSFC perovskite and a small formation of secondary phases, with nanometric crystallite sizes (9–20 nm). SEM analysis revealed the loose and porous structure of the powder materials. Densification studies were carried within 950–1100 °C, showing that porosity decreased with increasing sintering temperature. Electrical conductivity was measured in the temperature range 300–800 °C and correlated with the sintering temperature.

1. Introduction

Solid oxide fuel cells (SOFCs) are promising, efficient, energy-saving, and environment-friendly energy conversion devices that generate electricity and heat [1]. However, its high operation temperature limits the choice of proper materials and decreases the durability. The challenge now is to develop materials with good performance at intermediate temperatures (600–800 °C) for SOFCs, allowing it to reduce the cost of the cells, increasing the long-term stability and decreasing the time of startup and shutdown.

$La_{1-x}Sr_xCo_{1-y}Fe_yO_3$ (LSCF) is attracting substantial interest as a promising cathode material for IT-SOFCs because of its excellent properties, such as chemical and thermal stabilities, high catalytic activity for the oxygen reduction and high electrical conductivity [1,2].

For obtaining materials with good properties, the synthesis method, composition and sintering temperature are critical in determining the final morphology and microstructure of cathodes for IT-SOFC. Cathodes must have porosity of 20–40% for a proper conduction of O_2 molecules to the reaction sites at the electrolyte interface [1]. A coarse structure improves the gas permeability and ionic and electronic conductivities, while a fine structure leads to a high specific surface area and therefore to a great number of reaction sites [2].

Several synthesis methods have been developed for preparation of perovskite powders, such as solid-state reaction, combustion method and some solution chemistry methods, for example, sol–gel process, co-precipitation technique, and citrate process [3–6]. The combustion method is particularly useful in the production of ultrafine ceramic powders with a small average particle size and high porosity. This is a simple method with the advantage of using inexpensive precursors and resulting nano-sized, homogeneous, highly reactive powders [7,8].

The most commonly used fuel in the combustion process for the perovskite synthesis is glycine [5,9–11]. However, urea, citric acid, oxalyl hydrazine and sucrose have also been recently utilized as complexing agents and fuels in the combustion synthesis [12–15]. The combustion synthesis technique consists in bringing a saturated aqueous solution of the desired metal salts and a suitable organic fuel to boil, until the mixture ignites and a self-sustaining and rather fast combustion reaction takes off, resulting in a dry, usually crystalline, fine oxide powder [16].

The objective of this work is to study the effect of different propellants (urea, glycine, citric acid and sucrose) in the preparation of $La_{0.7}Sr_{0.3}Co_{0.5}Fe_{0.5}O_3$ (LSCF) powders by the combustion method. The influence of the nature of the propellant will be evaluated on the structural and morphological properties of the prepared powders. We also evaluated the porosity and

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