11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Combustion synthesis of doped ceria based electrolyte

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Abstract – A series of powders with the general formula of $Ce_{0.8}Gd_{0.2-x}La_xO_{1.9}$ (with x=0; 0.05; 0.1; 0.15 and 0.20) were prepared by solution combustion route using an aqueous solution of cerium nitrate, gadolinium nitrate, lantanium nitrate and glycine. In the experiments glycine to nitrate molar ratio was taken as 0.53. The aqueous solution on heating formed gel before combustion and a single-phase fluorite structure of ceria powder after the combustion reaction has been obtained. The increase of La content in the ceria compounds results in the increase linear of the lattice parameter. The combustion synthesized powders sintered at 1350 ºC results in pellets with density higher than 94% of theoretical density.

Doped ceria based compounds have been considered as one of the most promising materials for IT-SOFC applications and a wide variety of processes are available for synthesis of its powders. Doped ceria powder has been reported to be synthesized by various wet chemical routes, such as, co-precipitation, hydrothermal, sol-gel, salt-assisted aerosol decomposition and solution combustion route. Controlling the parameters these wet chemical processes can produce nano-sized powders in narrow particle size distribution. The ultrafine powder contributes to decrease the sintering temperature and to get dense sintered pellet. The combustion process is characterized by fast reaction rate and low cost. In the solution combustion route a self-sustaining exothermic redox reaction is allowed to take place in the gel that is formed on dehydrating an aqueous solution of a fuel and an oxidant[1]. In this study a set of samples with general formula of $Ce_{0.8}Gd_{0.2-x}La_xO_{1.9}$ (with x=0; 0.05; 0.1; 0.15 and 0.20) were prepared by solution combustion route using an aqueous solution of cerium nitrate, gadolinium nitrate, lantanium nitrate and glycine. The fuel to nitrate molar ratio has been taken as per stoichiometric reaction, 0.53. The as-colected ash was calcined at 600 ºC in air for 2 h. The crystal structures of calcined powders were characterized by X-ray diffraction measurements (DRX) and a single-phase fluorite structure for all compositions was obtained. It was found that the 2θ values of the ceria compounds doped with La shift slightly towards lower angles when x varies from 0 to 0.2. It is because the ionic radius of La^{3+} is larger than that Gd^{3+}, the substitution of Gd^{3+} with La^{3+} caused the increase of the lattice constant, following the Vergad law suggesting that all the La doped ceria samples of this work are ceria based-solid solutions. The crystallite size calculated by Scherrer's formula was found decrease slightly with the increase of La content in the ceria compounds. The calcined powders were uniaxially dry-pressed into pellets at 98 MPa. The pellets were sintered at 1350 ºC for 3 h. The apparent density of all compositions of sintered ceria compounds studied here was calculated using the Archimedes' principle resulting in pellets with density higher than 94% of theoretical density determinate from X-ray data using free software named CellRef. The combustion synthesis of doped ceria using a solution of cerium nitrate, gadolinium nitrate, lantanium nitrate and glycine can produce doped ceria ultrafine powders in a fast and low cost process for IT-SOFC applications.

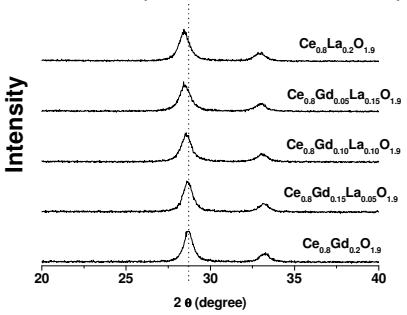

Figure 1: X-Ray patterns of $Ce_{0.8}Gd_{0.2-x}La_xO_{1.9}$ (with x=0; 0.05; 0.1; 0.15 and 0.20).

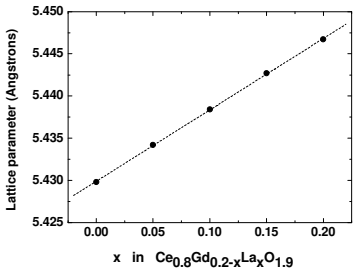

Figure 2: Lattice parameters of $Ce_{0.8}Gd_{0.2-x}La_xO_{1.9}$ (with x=0; 0.05; 0.1; 0.15 and 0.20).

References

[1] S. R. Jain, K. C. Adiga, V. R. Pai Venekar, Combust. Flame. 40 (1981) 71-79.