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INFLUENCE OF CALCIUM (CA) AND LANTHANUM (LA) DOPANTS ON THE ELECTRICAL AND MICROSTRUCTURAL PROPERTIES OF CERIA

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Introduction

Fuel cells are electrochemical devices that convert chemical energy into electrical energy through reactions between hydrogen and oxygen, producing water and heat as by-products. Among the materials used in solid oxide fuel cells (SOFCs), doped ceria has attracted attention due to its mixed ionic-electronic conductivity at intermediate temperatures. The electrical properties of ceria depend on factors such as dopant concentration, oxygen vacancies, and microstructure. Recent studies have demonstrated the feasibility of substituting lanthanum with calcium, aiming to reduce costs while maintaining high ionic conductivity. Additionally, the synthesis route strongly influences particle morphology, grain size, and conductivity. Therefore, this work investigates calcium-doped ceria synthesized by solution combustion using sucrose as fuel, evaluating its microstructural and electrical properties for SOFC applications.

Objectives

Investigate the microstructural and electrical properties of calcium-doped ceria ($Ce_{0.9}Ca_{0.1}O_{1.9}$) synthesized by solution combustion using sucrose as fuel, evaluating its potential for application as an electrolyte in solid oxide fuel cells (SOFCs).

Methodology

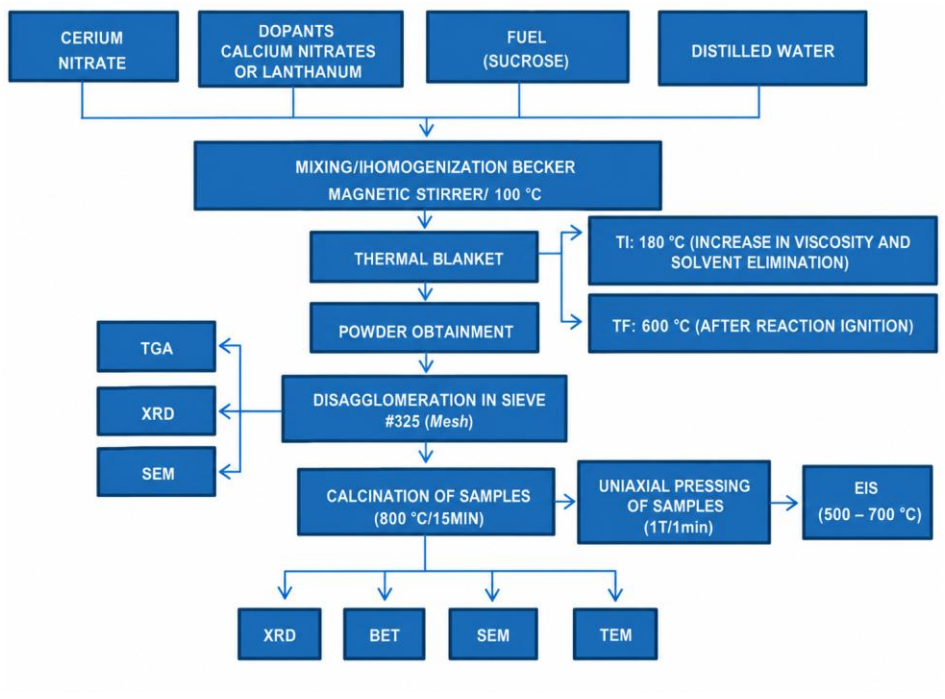
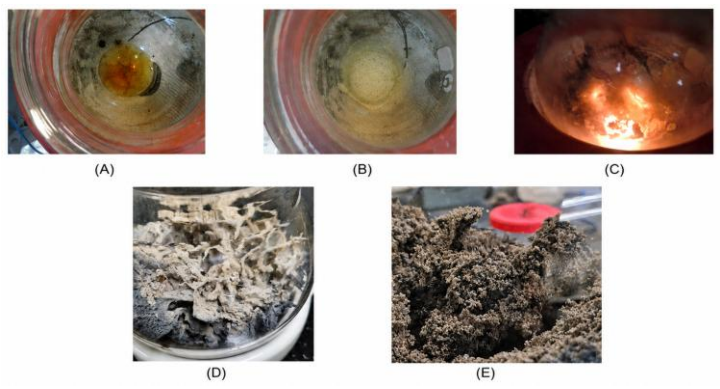
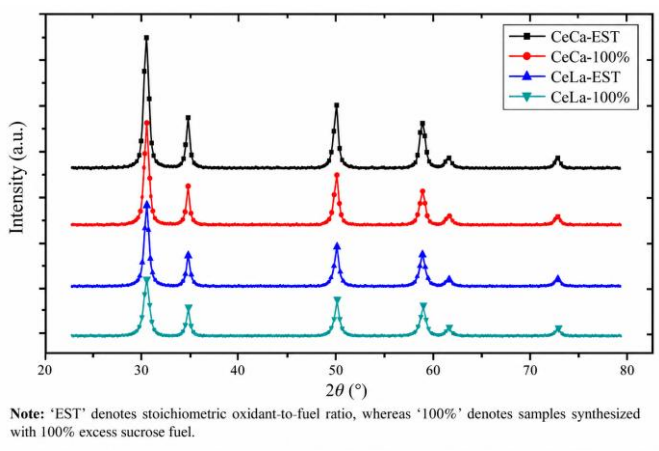


Figure 1: (A) Precursor solution before ignition; (B) onset of foam formation due to gas release; (C) self-sustaining combustion with heat and light release; (D) product obtained after cooling inside the reactor; (E) resulting powder exhibiting a cavernous structure.



Results and Discussion

Figure 2: XRD patterns for (calcined) calcium-doped and lanthanum-doped ceria powders with varying amounts of fuel.



Note: 'EST' denotes stoichiometric oxidant-to-fuel ratio, whereas '100%' denotes samples synthesized with 100% excess sucrose fuel.

Figure 3: TEM micrographs of calcined CeLa-STOICH powders with scale bars of (A) 100 nm and (B) 50 nm

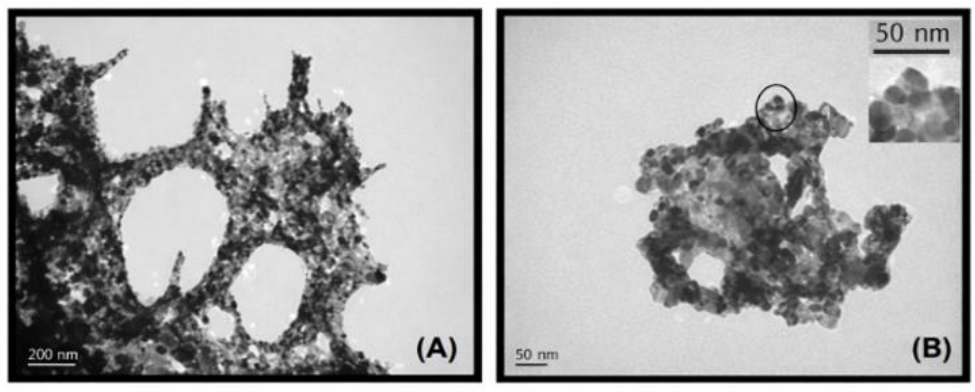


Table 1: Crystallite size after calcination, specific surface area, and the E1sc and E2sc energy values for the CeCa and CeLa samples synthesized under different conditions.

Sample	Crystallite size (nm)	Specific surface area (m^2/g)	E_1 (eV)	E_2 (eV)	Log(σ_1) at 700 °C	Log(σ_2) at 700 °C
CeCa-EST	27.35	9.12	1.39	1.75	−4.43	−4.70
CeCa-100%	28.68	8.32	1.22	1.41	−5.02	−5.16
CeLa-EST	15.93	9.11	1.12	1.39	−4.80	−5.02
CeLa-100%	15.92	7.09	1.31	1.34	−4.52	−4.70

Note: E_1 and E_2 represent the activation energies associated with the first and second semicircles, respectively. σ_1 and σ_2 are the corresponding conductivities calculated from the impedance data at 700 °C.

Conclusions

The results demonstrated that solution combustion synthesis is an effective and low-cost route for obtaining calcium- and lanthanum-doped ceria powders for SOFC applications. X-ray diffraction confirmed the formation of crystalline phases, while the powders exhibited nanometric crystallite sizes and specific surface areas ranging from 7.09 to 9.12 m²/g. The fuel concentration influenced the microstructural characteristics of the synthesized powders.

Electrical characterization revealed thermally activated conduction behavior in all samples. At 700 °C, the logarithmic conductivity values (log σ_1) ranged from −5.02 to −4.43 for calcium-doped ceria and from −4.80 to −4.52 for lanthanum-doped ceria. For the samples synthesized under stoichiometric conditions, CeCa-EST exhibited a higher conductivity than CeLa-EST, whereas CeLa-100% exhibited a higher conductivity than CeCa-100%. These results demonstrate that the electrical performance depends on both the dopant and the fuel composition. Overall, calcium-doped ceria shows promising potential as an alternative to lanthanum-doped ceria for SOFC applications.

References and Acknowledgments

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