

Synthesis and stabilization of highly conductive cubic SrCoO₃ to increase solid oxide fuel cell efficiency

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INTRODUCTION

SrCoO₃ is an important perovskite parent compound used for development of a variety of functional materials. As is shown in literature structural properties of different materials can change in different environments, operation temperatures and oxygen partial pressures [1-8]. Additionally, in ceramics such as SrCoO₃ thermal history and synthesis process can be important factors in displaying multiple crystal structures [9]. Replacement of 20% of cobalt with iron is shown to improve the electric conductivity of this material SrCoO₃ [10]. The perovskite SrCo_{0.8}Fe_{0.2}O₃ can display mixed ionic and electronic conducting properties (MIEC) which makes this oxide useful for a variety of applications, including fabrication of oxygen separation membranes, combustion catalysts and importantly cathode/anode materials for solid oxide fuel cells (SOFC), a device that can produce electricity directly from fuels such as hydrogen and methane [11,12]. Important to our research is the cubic structure of this material which possesses the highest electronic and oxygen ionic conductivity with a reported total electric conductivity of 160 S.cm⁻¹ at 950° C [13]. It is shown that substitution of various elements in the A and B site of this material can increase the stability of its cubic crystal structure. In this study, we have adopted a strategy of element substitution in the A site of the SrCo_{0.8}Fe_{0.2}O₃ perovskite to stabilize its cubic crystal structure, which is believed to result in an improvement of the electric conductivity of this material.

METHODS

Ceramics were synthesized using co-precipitation method. the precipitation pH of at least 8 is required for the precipitation to be completed. The precipitates are subsequently calcined at a temperature of 1000°C to achieve the perovskite. The structure of synthesized ceramics is then studied using X-ray diffraction (Philips PW-1730) and scanning electron microscopy (TESCAN-MIRA3)

RESULTS

SrCo_{0.8}Fe_{0.2}O₃ (SCF) and A site barium doped SCF were synthesized by a novel co-precipitation method to examine the effect of barium substitution on stabilization of the SCF cubic lattice. After synthesis, the obtained crystal structures were analyzed to evaluate the success of our co-precipitation method.

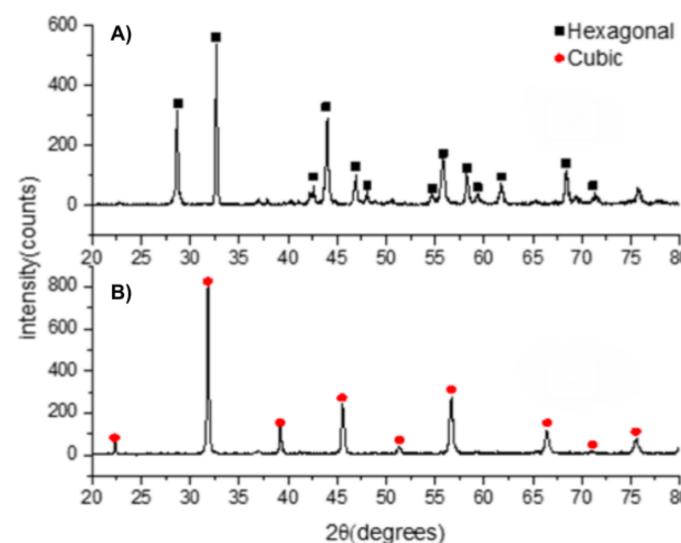


Fig. 1. XRD image of (1.A) hexagonal SrCo_{0.8}Fe_{0.2}O₃ and cubical Ba doped SrCo_{0.8}Fe_{0.2}O₃

Our results show that by replacement of 50% strontium with barium, the hexagonal structure of SCF at room temperature was changed to cubic (Fig. 1A & Fig.1B). Modification of the temperature and environment of synthesis further increased the success in achieving a pure cubic-perovskite phase. Figure 2 shows SEM image of the cubical perovskite structure.

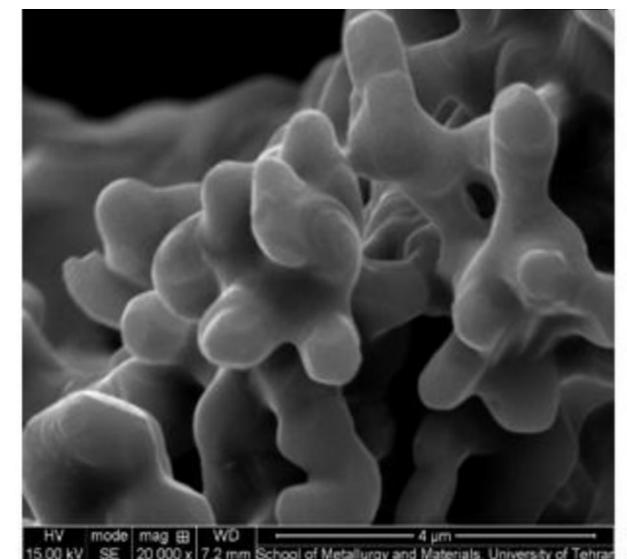


Fig. 2. Scanning electron microscopy of cubical Ba doped SrCo_{0.8}Fe_{0.2}O₃.

CONCLUSIONS

Our strategy can result in a more stable cubic structure of SCF perovskite oxide. This new perovskite with the chemical formula Ba_{0.5}SrCo_{0.8}Fe_{0.2}O₃ can be used in fabrication of device compartments with higher electronic and oxygen ionic conductivity such as new class of cathodes for SOFCs. These new fuel cell devices can potentially increase the efficiency and performance of solid oxide fuel cells and eventually result in significantly lower costs the production electricity.