48ª Reunião Anual da Sociedade Brasileira de Química

Emergências Climáticas?
A Química Age e Reage!

ANAIS

08 a 11 de junho de 2025, Campinas, Expo Dom Pedro

Revisão textual e gramatical: Resposanbilidade dos respectivos autores.

Dados Internacionais de Catalogação na Publicação (CIP)
(Câmara Brasileira do Livro, SP, Brasil)

Reunião Anual da SBQ (48. : 2025 : Campinas, SP)
Anais da 48ª Reunião Anual da SBQ [livro eletrônico] / Sociedade Brasileira de Química. -- 1. ed. -- Campinas, SP : Aptor Software, 2025.
PDF

Vários autores.
Vários colaboradores.
Bibliografia.
ISBN 978-85-63273-70-3

1. Química I. Sociedade Brasileira de Química. II. Título.

25-282696 CDD-540

Índices para catálogo sistemático:

1. Química 540

Eliete Marques da Silva - Bibliotecária - CRB-8/9380

Área: MAT
(Inserir a sigla da seção científica para qual o resumo será submetido. Ex: ORG, BEA, CAT)

Synthesis and characterization of perovskite electrolyte - $BaZr_{0.25}Ce_{0.25}Pr_{0.25}Zn_{0.25}O_{3-\delta}$ – for manufacturing solid oxide fuel cells - SOFC

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Keywords: *SOFC; solid oxide fuel cell; electrolyte; electrochemical, perovskite; electrochemical impedance*

Highlights

The work highlights the physicochemical and electrochemical behavior of the electrolyte $BaZr_{0.25}Ce_{0.25}Pr_{0.25}Zn_{0.25}O_{3-\delta}$ synthesized by the solid state method, aiming to prepare a SOFC of this material.

Abstract

Solid oxide fuel cells – SOFC – allow you to generate clean energy, such as H_2 efficiently, using low-cost materials. However, SOFCs operate at high temperatures (800-1000°C), and the challenge in the area is to reduce the working temperature. In the present work, a maximum entropy perovskite $BaZr_{0.25}Ce_{0.25}Pr_{0.25}Zn_{0.25}O_{3-\delta}$ was synthesized, composed of the elements Ba, Zr, Ce, Pr and Zn, to act as an electrolyte in SOFC, with the objective of reducing the temperature of work. Its physicochemical properties were characterized by TGA, XRF, XRD and its morphology by SEM. Furthermore, the resistance and conductivity properties were studied by electrochemical impedance spectroscopy. The electrolyte was prepared by solid state synthesis, in which the salts were poured into a zirconia cup and stirred in a ball mill for 6 hours. Afterwards, the material was heat treated at 800°C for 2 hours. To study the formation and densification of single-phase perovskite, the sintering temperature was adjusted from 1200-1300°C. According to the results, from the TGA curve, it was observed that the counterions had left during heating, leaving the metal oxides in the composition. The XRF measurements highlighted that the experimental stoichiometric composition agrees with the theoretical one, corresponding to 1.0 mol of Ba and 0.25 mol of Zr, Ce, Pr and Zn. In the sintering study, at 1200°C, the electrolyte formed the single perovskite phase observed by XRD. However, the material did not densify, as demonstrated by the SEM images, since liquid was passing through its pores. Thus, the temperature was raised to 1300°C,which resulted in phase segregation, with the division of some peaks of the single phase in the X-ray spectrum. The material had densified, as seen in the SEM images, not allowing the passage of liquid through the pores of the material. The temperature lowered to 1250°C, which was ideal as the single phase formed and densified. Sintering processes within this temperature range shrink the inserts to around 15% of the initial diameter. The resistance and conductivity of the material were investigated by varying the temperature from 400-800°C. From the electrochemical impedance measurements, it was observed that the values varied from $1.5x10^{-4}$ (S cm^{-1}) at 400°C to $3.5x10^{-2}$ (S cm^{-1}) at 800°C, when the tests were carried out for sintered inserts at 1200-1300°C.

Acknowledgments

The authors would like to thank the funding agencies CNPq, FAPESP, Shell and CAPES for funding.