UNIVERSITI TEKNOLOGI MARA

CHARACTERIZATION OF Y^{3+} DOPED- $Ba(Ce,Zr)O_3$ INCORPORATED WITH NiO COMPOSITE ANODE FOR PROTON CONDUCTING FUEL CELL APPLICATION

SHAZANA BINTI MOHD SENARI

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Shazana Binti Mohd Senari
Student I.D. No.	:	2014737127
Programme	:	Master of Science (Applied Chemistry) – AS757
Faculty	:	Applied Sciences
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Signature of Student	:	……..
Date	:	September 2020

ABSTRACT

The high polarization resistance which contribute by electrode at intermediate temperature operation (500-800°C) is one of the major challenges in the development of proton conducting fuel cells (PCFCs). In this study, the focus was specified on anode part where the oxidation process takes place. The work was divided into three parts where the first part was given on the selection of NiO-$Ba(Ce_{0.6}Zr_{0.4})_{0.9}Y_{0.1}O_{3-\delta}$ (NiO-BCZY) ratio (40:60, 50:50 and 60:40) and the best composition is proceed to the synthesis of NiO-BCZY composite anode powder by three different synthesizing methods; evaporation and decomposition of solution and suspension method (EDSS), one-step sol-gel method and two-step sol-gel method. Then, the second part was directed towards the characterization of the selected NiO-BCZY composite anode in form of pellet. To prove the capability of the NiO-BCZY composite anode in PCFC application, an anode supported single button cell with configuration of NiO-BCZY|BCZY|LSCF (LSCF: $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$) was fabricated as a function of BCZY electrolyte layer in part three. The synthesized NiO-BCZY composite anode powders were characterized by Fourier Transform Infrared (FTIR) Spectroscopy, X-ray Diffractometer (XRD) and Field Emission Scanning Electron Microscopy/Energy Dispersive X-ray (FESEM/EDX). The structural and microstructural study of composite anode pellet was examined by XRD and FESEM analysis. The electrochemical performance of the composite anode pellet and single button cell with 3 layers (SC_3L) and 10 layers (SC_10L) of electrolyte were evaluated using Electrochemical Impedance Spectroscopy (EIS). The power density of the single button cell was measured by in-house developed SOFC test station. As corroborated by the FTIR, XRD and FESEM/EDX analyses, the one-step sol-gel method produced excellent phase stability and better characteristic in term of microstructural and morphological properties as compared to the two-step sol-gel method and EDSS method. For the characterization of composite anode pellet, XRD analysis confirmed the formation of Ni-BCZY composite anode and the FESEM images showed the porous anode pellet after undergo the reduction process under wet H_2:N_2 (10%:90%). Moreover, the increasing of conductivity in wet H_2:N_2 (10%:90%) verified that the NiO in the composite anode was reduced to Ni metal. The evaluation of electrochemical performance of the Ni-BCZY composite anode in an anode supported single button cell revealed that the obtained polarization resistance is comparable with other single button cell in literatures. The polarization resistances as well as the ohmic resistances of the single button cells decreased as the operating temperature increased. This observation shows that the involved reaction is thermally activated process. However, the SC_3L exhibited better performance with polarization resistances (R_p=0.52 Ωcm^2) compared to SC_10L (R_p=6.31 Ωcm^2). The performance of SC_3L was further tested using fuel cell test station and shown a good power density of 332 mW cm^{-2}. In conclusion, the NiO-BCZY synthesized by one-step sol-gel method has the ability to produce a composite anode powder with good structural and microstructural characteristics. The application of NiO-BCZY in single button cell has surprisingly results in the significant improvement for single button cell performance.

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