UNIVERSITI TEKNOLOGI MARA

SYNTHESIS AND CHARACTERIZATION OF Y^{3+} DOPED $Ba(Ce,Zr)O_3$ CERAMIC MATERIAL AIDED WITH FUNCTIONALIZED ACTIVATED CARBON

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Thesis submitted in fulfilment
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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.

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ABSTRACT

Yttrium doped barium cerate-zirconate (BCZY) has been extensively utilized as an electrolyte material for proton ceramic fuel cells (PCFCs). Recently, much research has reported on the utilization of the BCZY material as a composite electrode component for PCFCs application. Therefore, more research has been conducted by tailoring the nanostructure of the BCZY materials to improve their quality and performance. In this work, two steps were employed to modify the structure of BCZY powders by utilizing activated carbon (AC) from empty fruit bunches as a dispersing agent during the synthesizing processes. A dispersing agent assisted in separating particles and improved the microstructure of ceramic powder. The first step was the functionalization of AC by using an acid treatment method to remove impurities and activate the functional group on the surface of AC. The acid reagents used for the treatment were hydrogen peroxide (H_2O_2), nitric acid (HNO_3), sulphuric acid (H_2SO_4) and a mixture of HNO_3/H_2SO_4. The second step was the addition of AC as a dispersing agent to the BCZY powders synthesized by a modified sol-gel method. The pristine BCZY, modified BCZY with untreated AC (*u*-AC BCZY) and modified BCZY with functionalized AC (*f*-AC BCZY) powders were physically and chemically characterized. The functionalized AC with HNO_3/H_2SO_4 (*f*-AC) produces a more stable suspension than other samples indicating the presence of oxygen-containing groups attached to the surface of AC based on the dispersion test. This finding was confirmed by Fourier transform infrared (FTIR) spectroscopy analysis, and the *f*-AC has been chosen as a dispersing agent. For the characterization of BCZY powders, the FTIR and X-ray diffraction (XRD) results confirmed the decomposition of the intermediate compounds in all powders, promoting the formation of a single BCZY perovskite phase. For pristine BCZY, *u*-AC BCZY, and *f*-AC BCZY, their surface areas are 5.61 m^2/g, 7.6 m^2/g and 7.77 m^2/g and particle sizes are ~80 nm, ~50 nm, and ~60 nm, respectively. The addition of AC as a dispersing agent has reduced the particle size of BCZY powder. Meanwhile, energy-dispersive X-ray (EDX) data showed the presence of silica impurity in *u*-AC BCZY. However, the presence of an impurity in *u*-AC BCZY interrupted the ion conduction. In addition, the conductivity of dense pristine BCZY (>91%) and *u*-AC BCZY (>92%) pellets are $3.89x10^{-3}$ Scm^{-1} and $4.83x10^{-4}$ Scm^{-1}, while the porous *f*-AC BCZY pellet (<74%) is $9.86x10^{-4}$ Scm^{-1}, respectively. Low conductivity of the *f*-AC BCZY pellet may result from pores that interrupting the charge carrier's conduction. Thus, *f*-AC BCZY is more suitable as a composite electrode component than as an electrolyte material.

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