

UNIVERSITI TEKNOLOGI MARA

**SYNTHESIS AND
CHARACTERIZATION OF
LANTHANUM COBALTITE BASED
CATHODE MATERIAL FOR
POTENTIAL APPLICATION IN
PROTON CONDUCTING FUEL
CELL**

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of the requirements for the degree of
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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 30th June 2014 to conduct the final examination of Abdullah bin Abdul Samat on his Master of Science thesis entitled “Synthesis and Characterization of Lanthanum Cobaltite Based Cathode Material for Potential Application in Proton Conducting Fuel Cell” in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of examiners was as follows:

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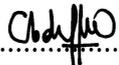
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AUTHOR'S DECLARATION

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

Proton conducting fuel cell (PCFC) is a device that converts chemical energy directly into electrical energy via electrochemical processes. Currently, one of the targets to boost the commercialization of this device is by lowering the current high operating temperatures (800 – 1000 °C) to intermediate temperatures (IT) (500 – 800 °C). However, at reduced temperatures, the device has performed a high interfacial polarization resistance (R_p) at cathode|electrolyte interface. In this work, strontium-doped lanthanum cobaltite, $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_{3-\delta}$ (LSCO64) was chosen as cathode material as it has shown a good performance at IT. The LSCO64 powder was synthesized via polymeric complexing method using metal nitrate salts as precursor material. The calcined LSCO64 powder was transformed to cathode slurries which have been prepared using four different electrode binders namely ethyl cellulose (EC), polyvinyl alcohol (PVA), polyvinyl butyral (PVB) and polyvinyl pyrrolidone (PVP). These slurries were separately painted on pellet surfaces of yttrium-doped barium cerate-zirconate, $\text{BaCe}_{0.54}\text{Zr}_{0.36}\text{Y}_{0.1}\text{O}_{2.95}$ (BCZY64) electrolyte to produce half-cell of LSCO64|BCZY64|LSCO64. The obtained powders and fabricated half-cells were respectively characterized by employing Thermogravimetric Analysis (TGA), Fourier Transform Infrared (FTIR) Spectroscopy, X-ray Diffractometry (XRD), Scanning Electron Microscopy/Electron Dispersive X-ray Spectrometry (SEM/EDS) and Electrochemical Impedance Spectroscopy (EIS). The TGA results showed the lowest total weight loss, W_{TL} (~86%) and the lowest thermal decomposition temperature, T_{td} (600 °C) were recorded at heating rates of 5 °C min⁻¹ and 2 °C min⁻¹, accordingly. The XRD and SEM analysis revealed that a single perovskite phase of LSCO64 with small particle size (~130 – 260 nm), respectively was obtained at calcination temperature of 800 °C with heating/cooling rate of 5 °C min⁻¹. The presence or absence of carbonyl compounds at ~1600 cm⁻¹ and ~860 cm⁻¹ and metal-oxide (M-O) bond at 700 – 400 cm⁻¹ after heat treatment was proven by the FTIR. SEM micrographs at cross-sectional view of the prepared cells with different electrode binders showed there were three areas corresponding to the LSCO64, BCZY64 and LSCO64|BCZY64 interface with or without crack and/or hole. Among all the electrode binders, only PVP has aided to form a good contact between the LSCO64 and BCZY64 with no formation of crack and/or hole at LSCO64|BCZY64 interface region. The elemental atomic percentage of elements at the interface region of the cell prepared with the PVP such as lanthanum, La (3.16%), barium, Ba (9.52%) and cerium, Ce (6.02%) was detected by EDS. The EIS results showed the R_p values in terms of area specific resistance (ASR) decreased as temperatures increased from 400 °C to 800 °C. A relatively low R_p of 0.48 Ω cm² at 700 °C indicates that the LSCO64 is a promising cathode material for the PCFC at intermediate temperatures.

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