

UNIVERSITI TEKNOLOGI MARA

**SYNTHESIS, CHARACTERIZATION
AND BAND GAP STUDIES OF
 η -Al₂O₃, η -Al_{1.9}Fe_{0.1}O₃ AND
 η -Al_{1.9}Ni_{0.1}O₃ NANOSTRUCTURED
MATERIALS OBTAINED *VIA* SELF-
PROPAGATING COMBUSTION
(SPC) METHOD**

MAWAR HAZWANI JASIMIN

Thesis is submitted in fulfilment
of the requirements for the degree of
Master of Science

Faculty of Applied Sciences

October 2015

CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 30th April 2015 to conduct the final examination of Mawar Hazwani Binti Jasimin on her Master of Science thesis entitled “Synthesis, characterization and band gap studies of η -Al₂O₃, η -Al_{1.9}Fe_{0.1}O₃ and η -Al_{1.9}Ni_{0.1}O₃ nanostructured materials obtained *via* self-propagating combustion (SPC) method” 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:

Ahmad Saat, PhD
Associate Professor
Faculty of Applied Science
Universiti Teknologi MARA
(Chairman)

Tan Winie, PhD
Faculty of Applied Science
Universiti Teknologi MARA
(Internal Examiner)

Mohamad Azmi Bustam@Khalil, PhD
Associate Professor
Chemical Engineering Department
Universiti Teknologi PETRONAS
(External Examiner)

SITI HALIJAH SHARIFF, PhD
Associate Professor
Dean
Institute of Graduates Studies
Universiti Teknologi MARA
Date: 13rd October 2015

AUTHOR'S DECLARATION

I declare that work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my 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.

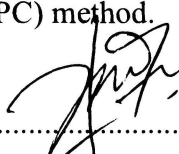
Name of Student : Mawar Hazwani Binti Jasimin

Student I.D. No. : 2010578629

Programme : Master in Science (Research)

Faculty : Faculty of Applied Sciences

Thesis Title : Synthesis, characterization and band gap studies of η -Al₂O₃, η -Al_{1.9}Fe_{0.1}O₃ and η -Al_{1.9}Ni_{0.1}O₃, nanostructured materials obtained *via* self-propagating combustion (SPC) method.

Signature of Student : 

Date : October 2015

ABSTRACT

η - Al_2O_3 is one of the metastable phases of aluminum oxide and known to be a very important support material for heterogeneous catalysts used extensively in the chemical industry. This phase is not easy to obtain. In this research, the η -phase is synthesized using a novel method, the self-propagating combustion (SPC) and the properties of η - Al_2O_3 and doped η - Al_2O_3 nanostructured materials were investigated. The synthesis parameters are optimized to obtain pure and single phase η - Al_2O_3 , η - $\text{Al}_{1.9}\text{Fe}_{0.1}\text{O}_3$ and η - $\text{Al}_{1.9}\text{Ni}_{0.1}\text{O}_3$ nanomaterials. Materials characteristics inclusive of thermal behaviour, phase, stoichiometry structure, morphology and crystallite size were studied. Results showed that the substitution of Al with other metals (Ni, Fe) without changing the crystal structure affects the characteristics of material as well as their band energies. In this study, the effect of temperature on the phase formation of η - Al_2O_3 , η - $\text{Al}_{1.9}\text{Fe}_{0.1}\text{O}_3$ and η - $\text{Al}_{1.9}\text{Ni}_{0.1}\text{O}_3$ were investigated. It was found that the annealing temperature has to be optimized to obtain pure η -phase. Pure and single phase η - Al_2O_3 , η - $\text{Al}_{1.9}\text{Fe}_{0.1}\text{O}_3$ and η - $\text{Al}_{1.9}\text{Ni}_{0.1}\text{O}_3$ were successfully obtained by annealing for 24 hours at 700 °C to 850 °C, 700 °C to 800 °C, 700 °C to 900 °C, respectively. The band gap energies for η - Al_2O_3 , η - $\text{Al}_{1.9}\text{Fe}_{0.1}\text{O}_3$ and η - $\text{Al}_{1.9}\text{Ni}_{0.1}\text{O}_3$ nanomaterials are between 6.29 to 6.55 eV, 3.26 to 3.19 eV and 5.6 to 5.96, respectively. Introduction of Fe^{3+} and Ni^{3+} ion in the η - Al_2O_3 material can narrow the band gap of the material. Thus, substitution of Fe^{3+} ions in the crystal lattice can result in the transformation of aluminium oxide material from insulator to semiconductor materials.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS	xvii

CHAPTER ONE: INTRODUCTION

1.1 Background of Study	1
1.2 Problem Statement	3
1.3 Significance of Study	4
1.4 Objective of Study	4
1.5 Scope of Study	4

CHAPTER TWO: LITERATURE REVIEW

2.1 Materials Science	6
2.2 Nanomaterials and Nanotechnology	7
2.3 Doping	8
2.4 Aluminium Oxide	9
2.4.1 Eta-Aluminium Oxide (η -Al ₂ O ₃)	10
2.4.2 Gamma-Aluminium Oxide (γ -Al ₂ O ₃)	11
2.4.3 Alpha-Aluminium Oxide (α -Al ₂ O ₃)	11
2.4.4 Doped Aluminium Oxide	12
2.4.4.1 Cr Doped Al ₂ O ₃	12
2.4.4.2 Co Doped Al ₂ O ₃	13