UNIVERSITI TEKNOLOGI MARA

PRODUCTION OF ACTIVATED CARBON FROM WASTE COCONUT SHELL VIA MICROWAVE IRRADIATION CARBONIZATION SYSTEM FOR SUPERCAPACITOR ELECTRODE

MOHD IQBALDIN BIN MOHD NAYAI

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Applied Science

August 2013

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 result of my own work, unless otherwise indicated or acknowledged as reference work. This thesis has not been submitted to any other academic institution or non-academic institution for any other 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	: Mohd Iqbaldin Bin Mohd Nayai
Student's ID No	: 2009676142
Programme	: Master of Science
Faculty	: Applied Sciences
Thesis Title	: Production of Activated Carbon from Waste Coconut Shell via Microwave Irradiation Carbonization System for Supercapacitor Electrode
Signature of Student	: .....
Date	: August 2013

ABSTRACT

Activation process for coconut shell was done by using chemical activation method of microwave-induced KOH technique in order to reduce the production time. The activation process was successfully carried out at power level of 100 to 1000W with irradiation time and impregnation ratio of 10 to 30min and 1.0 to 3.0, respectively. The surface area and pore size, surface morphology and specific capacitance of activated carbon produced were analyzed by using an automatic Quantachrome Instrument (Autosorb1C) volumetric sorption analyzer, Scanning Electron Microscope (SEM) and Automatic Battery Cycler, respectively. The best product produced at 20min of irradiation time with power level and impregnation ratio of 600W and 1.5 has a maximum surface area and specific capacitance value of $1768.8 m^2 g^{-1}$ and $156.33 Fg^{-1}$, respectively with the pores size range in mesopores (2.745nm) and 58% product yield. Response Surface Methodology (RSM) was used in order to get an optimum condition for the activation process. Three independent variables were chosen i.e. irradiation time, impregnation ratio and KOH concentration. Using RSM, the best conditions were chosen with irradiation time of 17.77min, impregnation ratio of 1.92 and concentration of KOH of 15%. It was found that the model used to get an optimal condition of coconut shell-based activated carbon (CSAC) seems to be valid with a model desirability of 0.810. Thus, based on the findings it can be concluded that the microwave irradiation system can be used as an alternative heating method to produce activated carbon in order to reduce the activation time.

ACKNOWLEDGEMENTS

In the name of Allah, the most merciful and the most gracious. Alhamdulillah, praise be to Allah S.W.T. for giving me the opportunity and strength to explore and complete this research study.

First of all, I wish to convey my deep and sincere appreciation, and special thanks to my main supervisor, Associate Professor Dr. Hj. Mohd Azlan Mohd Ishak and co-supervisors, Professor Dr. Hj. Khudzir Hj. Ismail, both from Universiti Teknologi MARA. Furthermore, I also wish to express my special thanks to my second co-supervisors, Dr. Surani Buniran from SIRIM AMREC Berhad for their supervision and invaluable guidance during my study. May Allah bless all of you.

Moreover, with this opportunity, I would like to express my gratitude to Ministry of Science, Technology and Innovation (MOSTI) Malaysia for awarding me the National Science Fellowship (NSF) scholarship in order to pursue and complete this research study.

To Fossil Fuels and Biomass Research Group members, Mohd Fauzi Abdullah, Zaidi Ab. Ghani, Muhammad 'Azim Jamaluddin and Mohd Fariz Yusof; their help, ideas and support throughout the study will always be remembered. To those who are direct or indirectly involved in this research work: Mr. Zubri Zakaria, Executive Researcher from SIRIM AMREC Berhad, other staffs from SIRIM AMREC Berhad; their cooperation is highly appreciated.

Further, I would like to thank to my wife, Fairuziana Binti Romli and my little sweet daughter, Irdina Insyirah for their support. I also would like to thank to my father, my mother and the whole family for their encouragement and financial support to me in order to finish this study.

Finally, I hope that the ideas, outcomes and findings from this research work will benefit and contribute to this area of knowledge.

CHAPTER ONE

INTRODUCTION

In this chapter, an overview of the importance of activated carbon, world activated carbon demands, energy storage, supercapacitor, problem statement, significance of study, scope and limitations and objectives of the research study are discussed. A schematic diagram summarizing the overall steps that have been executed in this study is shown at the end of this chapter.

1.1 IMPORTANCE OF ACTIVATED CARBON

Activated carbon (AC) also known as an activated charcoal is a carbonaceous material which plays an important role in adsorption process due to its high surface area. The AC has an ability to remove organic and inorganic chemical wastes, odors, colors and tastes from chemical industry processes are based on its amazing properties. The useful properties of the carbon material have been already discovered a long time ago. In the 18^{th} and 19^{th} century, a crude carbon was made from various materials such as blood, wood and animals, and was used for the purification of liquids. In fact, powdered crude of the activated material was made from a bone char (mostly calcium phosphate with only a small percent of carbon) and was used to de-colorize sugar (Patrick, 1995).

In Europe, early 19^{th} century, the commercialized AC powder was produced from wood (Pope, 1994) and it was used in large scale for water filtration and treatment in England. Interestingly, AC also played as an important role for decolorizing wastewater from textiles industries in the United States of America (US) (Cameron Carbon Incorperated [CCI], 2006). In early 20^{th} century the first plant to produce AC from vegetables material at an industrial scale was built for use in sugar refining.

Many researchers have revealed the significant properties and major roles of AC. However, the first industrial AC was actually produced by Fanto Works in 20^{th} century in Austria. In fact, the first Powdered Activated Carbon (PAC) was commercially produced