RESEARCH REPORT

ACTIVATED CARBON FROM JACKFRUIT PEEL WASTE: PREPARATION, CHARACTERIZATION, AND ITS APPLICATION ON METHYLENE BLUE ADSORPTION

By :

DEVARLY PRAHAS NRP: 5203003047

YOGA KARTIKA A.T. NRP: 5203003061

DEPARTMENT OF CHEMICAL ENGINEERING

ENGINEERING FACULTY

WIDYA MANDALA CATHOLIC UNIVERSITY

SURABAYA

2007

APPROVAL SHEET

The research entitled:

Activated Carbon from Jackfruit Peel Waste:

Preparation, Characterization, and Its Application on Methylene Blue Adsorption

Prepared and submitted by:

Name : Devarly Prahas

NRP : 5203003047

Has been approved and accepted as one of the requirements to achieve Bachelor of Engineering degree in Chemical Engineering Department, Engineering Faculty, Widya Mandala Catholic University Surabaya by following advisor and has been examined by the committees on June, 28th 2007.

Surabaya, July 3rd 2007

Supervisor I	Supervisor II
Ir. Suryadi Ismadji, M.T., Ph.D	Ir. M.G. Nani Indraswati
NIK. 521.93.0198	NIK. 521.86.0121

The Committees,

Chairman	Secretary
Felycia E. Soetaredjo, S.T., M. Phil	Ir. Suryadi Ismadji, M.T., Ph.D
NIK. 521.99.0391	NIK. 521.93.0198
Member	Member
Wenny Irawaty, S.T., M.T.	Prof. Ir. Mudjijati, Ph.D
NIK. 521.97.0284	NIK. 521.65.0005

Approved by,

Dean of Engineering Faculty	Head of Chemical Engineering Department
Ir. Rasional Sitepu, M.Eng	Ir. Suryadi Ismadji, M.T., Ph.D
NIK. 511.89.0154	NIK. 521.93.0198

APPROVAL SHEET

The research entitled:

Activated Carbon from Jackfruit Peel Waste:

Preparation, Characterization, and Its Application on Methylene Blue Adsorption

Prepared and submitted by:

Name : Yoga Kartika Adi Tandriana

NRP : 5203003061

Has been approved and accepted as one of the requirements to achieve Bachelor of Engineering degree in Chemical Engineering Department, Engineering Faculty, Widya Mandala Catholic University Surabaya by following advisor and has been examined by the committees on June, 28th 2007.

Surabaya, July 3rd 2007

Supervisor I

Ir. Suryadi Ismadji, M.T., Ph.D
NIK. 521.93.0198

Supervisor II

Ir. M.G. Nani Indraswati
NIK. 521.86.0121

The Committees,

Chairman

Felycia E. Soetaredjo, S.T., M. Phil
NIK. 521.99.0391

Secretary

Ir. Suryadi Ismadji, M.T., Ph.D
NIK. 521.93.0198

Member

Wenny Irawaty, S.T., M.T.
NIK. 521.97.0284

Member

Prof. Ir. Mudjijati, Ph.D
NIK. 521.65.0005

Approved by,

Dean of Engineering Faculty

Ir. Rasional Sitepu, M.Eng
NIK. 511.89.0154

Head of Chemical Engineering Department

Ir. Suryadi Ismadji, M.T., Ph.D
NIK. 521.93.0198

DECLARATION SHEET

I declare that this research was my own work and not the others' work, some or all except be written in the text. If it is known that this research is the others' work, I aware and accept the consequence that this research cannot be used as a requirement to achieve Bachelor of Engineering degree.

Surabaya, July 3rd 2007

The undergraduate student

Devarly Prahas
NRP. 5203003047

DECLARATION SHEET

I declare that this research was my own work and not the others' work, some or all except be written in the text. If it is known that this research is the others' work, I aware and accept the consequence that this research cannot be used as a requirement to achieve Bachelor of Engineering degree.

Surabaya, July 3rd 2007

The undergraduate student

Yoga Kartika A.T.
NRP. 5203003061

PREFACE

Thank God that through His blessing and grace, the authors could accomplish this research entitled **Activated Carbon from Jackfruit Peel Waste: Preparation, Characterization, Surface Chemistry and Its Application on Methylene Blue Adsorption.** This research was done in order to get **Bachelor of Engineering** degree in Chemical Engineering Department, Widya Mandala Catholic University Surabaya.

The authors would like to thank to some people since without their help the success of this research would have never been reached. They are:

1. Ir. Suryadi Ismadji, MT., Ph.D. and Ir. Nani Indraswati as our supervisors in this research for their guidance;
2. Prof. Ir. Mudjijati, Ph.D., Wenny Irawaty, ST., MT., and Felycia Edy Soetaredjo, ST., M.Phil. as the reviewers of this research;
3. Professor Max Lu, Mrs. Hiannie Djojoputro, Mr. Sandy Budi Hartono, and Ms. Laurentia Eka Kristanti from ARC Centre for Functional Nanomaterials, The University of Queensland Australia, for providing necessary laboratory facilities and analyzing several samples;
4. Martina, ST. for her suggestions and help for FTIR analysis of the products of our research;
5. Mr. Pudjo as the laboratory assistant of Process Technology Laboratory;
6. Mr Agus as the laboratory assistant of Unit Operations Laboratory;
7. Mr. Novi as the laboratory assistant of Organic Chemistry and Physic Chemistry Laboratory;
8. Our parents and friends who gave a lot of support;

9. Mirna and Thio for sharing their knowledge;
10. The others, who cannot be mentioned one by one, who helped us from the beginning of the research until the accomplishment of the report.

The authors realize that this report is imperfect. Therefore, the authors would be pleased to accept critics, comments and recommendations for further revision. The authors are looking forward that this report will be useful especially for the applied science and also for those who want to enlarge their knowledge about activated carbon. Finally, let the authors end this preface with what was said by Albert Einstein: "*Learn from the past, Live for today, Have hope for the future. And the most important thing, don't stop to hope.*"

CONTENTS

Title Page i

Approval Sheet ii

Declaration sheet iv

Preface vi

Contents viii

List of Tables x

List of Figures xi

Abstract xiii

Chapter I. Introduction I-1
1.1. Background I-1
1.2. Objectives I-4
1.3. Limitations I-5
1.4. Benefits I-5

Chapter II. Literature Review II-1
II.1. *Nangka Kunir* II-1
II.2. Adsorption II-2
II.3. Activated Carbon II-2
II.4. Production of Activated Carbon II-6
II.5. Surface Chemistry Characterization II-11
II.6. Adsorption Isotherm II-13
II.7. Adsorption Kinetics II-15

Chapter III. Research Material and Method III-1
III.1. Research Design III-1
III.2. Constant Variables III-2
III.3. Design Variables III-4
III.4. Material III-4
III.5. Apparatus III-5
III.6. Research Procedure III-6

Chapter IV. Results and Discussions IV-1
IV.1. Proximate Analysis IV-1
IV.2. Yield of Activated Carbon IV-1
IV.3. Physical Characterization of Resulting Carbons IV-3
IV.4. Surface Chemistry of Activated Carbons IV-14
IV.5. Methylene Blue Adsorption IV-20

Chapter V. Conclusion and Recommendation V-1
V.1. Conclusion V-1
V.2. Recommendation V-2

References R-1

Appendix A. Proximate Analysis A-1
A.1 Ash Content Analysis A-1
A.2 Moisture Content Analysis A-2
A.3 Volatile Matter Analysis A-3
A.4 Carbon Content Analysis A-4

Appendix B. Determination of Maximum Wavelength and Methylene Blue Standard Curve B-1
B.1 Preparation of Methylene Blue Solution B-1
B.2 Determination of Maximum Wavelength B-2
B.3 Preparation of Standard Curve B-3

Appendix C. Data Analyses C-1
C.1. Yield of Activated Carbon C-1
C.2. S_{BET} of Activated Carbon C-2
C.3. d_{002}, L_c, and L_a Calculation from XRD Patterns C-3
C.4. Boehm Titration C-4
C.5. pH Drift C-7
C.6. Methylene Blue Adsorption C-8

LIST OF TABLES

Table II.1. Differences between Physisorption and Chemisorption II-3
Table II.2. Differences between Physical and Chemical Activation II-8
Table IV.1. Proximate Analysis of Jackfruit Peels IV-1
Table IV.2. Characteristics of Activated Carbon Prepared From Jackfruit Peel IV-6
Table IV.3. Nanographitic Structures of Jackfruit Peel Activated Carbon IV-11
Table IV.4. Surface Chemistry of Jackfruit Peel Activated Carbon IV-16
Table IV.5. Percent Removal of Jackfruit Peel Activated Carbon for MB IV-21
Table IV.6. Pseudo Order 1 and 2 Fitted Parameters of The Adsorption of MB At Initial Different pH Condition IV-24
Table IV.7. Parameters of Langmuir Equation IV-25
Table IV.8. Parameters of Freundlich Equation IV-26
Table B.1. λ and Absorbance of 2.0 mg/L Methylene Blue solution B-2
Table B.2. Relationship between Concentration and Absorbance of Methylene Blue B-3
Table C.1. Production Yield of Activated Carbon C-1
Table C.2. The Position and the Width of (002) and (10) Peak of the XRD Spectra C-3
Table C.3. Experiment Data of Boehm Titration C-6
Table C.4. pH Final of Activated Carbon C-7
Table C.5. Experiment Data for the Determination of Methylene Blue Equilibrium Time C-8
Table C.6. % Removal of the Activated Carbons C-8
Table C.7. Data Analyses of Adsorption Kinetic of IR[4]T[550] at Different pH C-9
Table C.8. Data Analyses of Adsorption Isotherm of IR[4]T[550] at Different pH C-10

LIST OF FIGURES

Figure II.1. Nangka Kunir II-1
Figure II.2. Classification of Activated Carbon Pores II-4
Figure II.3. Examples of Functional Groups Present on the Surface of Activated Carbon II-11
Figure II.4. Adsorption Isotherms Curve Types II-14
Figure II.5. The IUPAC Classification of Adsorption Isotherm II-15
Figure III.1. Research Block Diagram III-7
Figure IV.1. Effect of Activation Temperature and Impregnation Ratio on the Yield of Activated Carbon IV-2
Figure IV.2(a). N_2 adsorption isotherm for activated carbon with HTT 350°C IV-4
Figure IV.2(b). N_2 adsorption isotherm for activated carbon with HTT 450°C IV-4
Figure IV.2(c). N_2 adsorption isotherm for activated carbon with HTT 550°C IV-4
Figure IV.3(a). Pore size distribution for activated carbon with HTT 350°C IV-7
Figure IV.3(b). Pore size distribution for activated carbon with HTT 450°C IV-7
Figure IV.3(c). Pore size distribution for activated carbon with HTT 550°C IV-7
Figure IV.4. SEM images of JPAC activated at HTT 350°C IV-9
Figure IV.5. SEM images of JPAC activated at HTT 450°C IV-9
Figure IV.6. SEM images of JPAC activated at HTT 550°C IV-10
Figure IV.7(a). SEM images of JPAC for IR[4]T[350] IV-10
Figure IV.7(b). SEM images of JPAC for IR[4]T[450] IV-10
Figure IV.7(c). SEM images of JPAC for IR[4]T[550] IV-10
Figure IV.8(a). XRD Patterns of Jackfruit Peel Activated Carbon with HTT 350°C IV-12
Figure IV.8(b). XRD Patterns of Jackfruit Peel Activated Carbon with HTT 450°C IV-12
Figure IV.8(c). XRD Patterns of Jackfruit Peel Activated Carbon with HTT 550°C IV-12
Figure IV.9. pH_{PZC} Determination Using pH Drift Method of IR[1]T[550] IV-15
Figure IV.10(a). Fourier Transform Infra Red Spectra for JPAC with HTT 350°C IV-17
Figure IV.10(b). Fourier Transform Infra Red Spectra for JPAC with HTT 450°C IV-17
Figure IV.10(c). Fourier Transform Infra Red Spectra for JPAC with HTT 550°C IV-17
Figure IV.11. Comparison of FTIR of Jackfruit Peel Activated Carbon with Impregnation Ratio 1 and HTT 350, 450 and 550°C and The Raw Material IV-18

Figure IV.12. Methylene Blue IV-20
Figure IV.13. Comparison of Pseudo-First-Order and Second-Order Models on MB Adsorption at pH 1.5, 6.0, and 10.0 ..... IV-23
Figure IV.14. Langmuir Equation on MB Adsorption at pH 1.5, 6.0, and 10.0 ..... IV-25
Figure IV.15. Freundlich Equation on MB Adsorption at pH 1.5, 6.0, and 10.0 ..... IV-26
Figure B.1. Methylene Blue Survey Scan B-2
Figure B.2. Standard Curve of Methylene Blue Solution B-3
Figure C.1. pH_{PZC} Determination Using pH Drift Method of IR[1]T[550] B-3

ABSTRACT

In order to study the utilization of jackfruit peel waste that has no economic value, activated carbon was prepared from jackfruit peel waste as an adsorbent using phosphoric acid as activating agent under nitrogen flow. The influence of impregnation ratio and activation temperature on the physical and chemical properties of the activated carbon was studied. The physical characterization of the activated carbon was identified by nitrogen adsorption at -196°C and also using Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD). The surface chemistry of the activated carbons was identified both qualitatively and quantitatively using Fourier Transform Infrared Spectroscopy (FTIR) and Boehm titration and pH drift method to determine functional groups on the surface of activated carbon. It was found that impregnation ratio and activation temperature have significant effects on both pore development and chemical surface characteristics of the activated carbon.

To study the performance of the activated carbon, Methylene Blue adsorption experiment was carried out. Under variation of initial pH, i.e. 1.5, 6.0, 10.0, adsorption kinetic and adsorption isotherm was investigated. Pseudo-first-order and pseudo-second-order models were used to evaluate the kinetic whether Langmuir equation and Freundlich models were developed to investigate the adsorption isotherm. It was found that pseudo-second-order, Langmuir equation, and Freundlich equation could represent the experimental data well. Methylene Blue is one of cationic dyes so that at pH solution more than pH_{PZC}, the activated carbon will be negatively charged. Ionic interaction between Methylene Blue cation and negatively charge surface of activated carbon would enhance the adsorption