

RESEARCH PROJECT

NANOCRYSTALLINE CELLULOSE FOR POTENTIAL APPLICATION OF DRUG DELIVERY



Submitted by:

Stephanie Novina Saputra NRP. 5203013005

Christian Julius Wijaya NRP. 5203013010

**DEPARTMENT OF CHEMICAL ENGINEERING
FACULTY OF ENGINEERING
WIDYA MANDALA CATHOLIC UNIVERSITY
SURABAYA**

2016

LETTER OF APPROVAL

The research entitled :

Nanocrystalline Cellulose for Potential Application of Drug Delivery

Which was conducted and submitted by :

Name : Stephanie Novina Saputra

Student ID : 5203013005

has been approved and accepted as one of the requirement for **Bachelor of Engineering** degree in Chemical Engineering Department, Faculty of Engineering, Widya Mandala Surabaya Catholic University by following supervisor/s and has been examined by the committees on May, 19th 2016.

Surabaya, May 26th 2016

Supervisor

Co-Supervisor


Suryadi Ismadji, Ph.D

NIK. 521.93.0198


Felicia Edy Soetaredjo, Ph.D

NIK. 521.99.0391

The Committees

Chairman

Secretary


Aning Ayucitra, S.T., M.EngSc

NIK. 521.03.0563


Suryadi Ismadji, Ph.D

NIK. 521.93.0198

Member

Member


Dra. Andriana Anteng A., M.Si

NIK. 521.86.0124


Sandy Budi Hartono, Ph.D

NIK.521.99.0401

Authorized by

Dean of
Engineering Faculty

Head of Chemical
Engineering Department


Suryadi Ismadji, Ph.D

NIK.521.93.0198


Wenny Irawaty, Ph.D

NIK.521.97.0284

LETTER OF APPROVAL

The research entitled :

Nanocrystalline Cellulose for Potential Application of Drug Delivery


Which was conducted and submitted by :

Name : Christian Julius Wijaya

Student ID : 5203013010

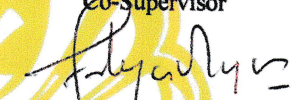
has been approved and accepted as one of the requirement for **Bachelor of Engineering** degree in Chemical Engineering Department, Faculty of Engineering, Widya Mandala Surabaya Catholic University by following supervisor/s and has been examined by the committees on May, 19th 2016.

Supervisor


Suryadi Ismadji, Ph.D
NIK. 521.93.0198


Surabaya, May 26th 2016

Co-Supervisor



Felicia Edy Soetaredjo, Ph.D
NIK. 521.99.0391

The Committees

Chairman


Aning Ayucitra, S.T., M.EngSc
NIK. 521.03.0563

Secretary


Suryadi Ismadji, Ph.D
NIK. 521.93.0198

Member

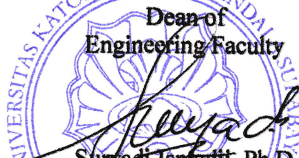

Dra. Andriana Anteng A., M.Si
NIK. 521.86.0124

Member


Sandy Budi Hartono, Ph.D
NIK. 521.99.0401

Authorized by

Dean of
Engineering Faculty


Suryadi Ismadji, Ph.D
NIK. 521.93.0198

Head of Chemical
Engineering Department


Wenny Irawaty, Ph.D
NIK. 521.97.0284

COPY RIGHT AGREEMENT

In order to support the development of science and technology, I am as the student of Widya Mandala Surabaya Catholic University:

Name : Stephanie Novina Saputra
Student ID : 5203013005

Agree to transfer the copyright of my thesis/paper :

Title :
Nanocrystalline Cellulose for Potential Application of Drug Delivery

To be published in internet or other media (Digital Library of Widya Mandala Surabaya Catholic University) for academic purposes according to copyright law in Indonesia.

Surabaya, May 26th 2016
Author,



Stephanie Novina Saputra
NRP. 5203013005

COPY RIGHT AGREEMENT

In order to support the development of science and technology, I am as the student of Widya Mandala Surabaya Catholic University:

Name : Christian Julius Wijaya
Student ID : 5203013010

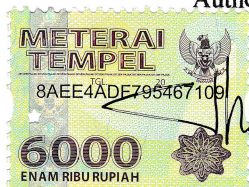
Agree to transfer the copyright of my thesis/paper :

Title :
Nanocrystalline Cellulose for Potential Application of Drug Delivery

To be published in internet or other media (Digital Library of Widya Mandala Surabaya Catholic University) for academic purposes according to copyright law in Indonesia.

Surabaya, May 26th 2016

Author,



Christian Julius Wijaya
NRP. 5203013010

LETTER OF DECLARATION

I declare that this research was my own work and does not contain any material that belongs to the others, unless it was stated in the references. Should it is known that this research belongs to others. I aware and accept the consequences that this research cannot be used as a requirement to achieve a **Bachelor of Engineering** degree.

Surabaya, May 26th 2016
Student,



Stephanie Novina Saputra
NRP. 5203013005

LETTER OF DECLARATION

I declare that this research was my own work and does not contain any material that belongs to the others, unless it was stated in the references. Should it is known that this research belongs to others. I aware and accept the consequences that this research cannot be used as a requirement to achieve a **Bachelor of Engineering** degree.

Surabaya, May 26th 2016
Student,



Christian Julius Wijaya
NRP. 5203013010

PREFACE

The authors would like to thank God for His blessing that the Research Project entitled Nanocrystalline Cellulose for Potential Application of Drug Delivery has been accomplished. This report is a prerequisite in achieving Bachelor of Engineering degree in Chemical Engineering.

The authors realize that the completion of this report is achieved by the help of many people. There for, the authors would like to thank the persons below:

- 1 Suryadi Ismadji, Ph.D as Principal Supervisor and Felycia Edi Soetaredjo, Ph.D as Co-Supervisor
- 2 Aning Ayucitra, S.T., M.EngSc as Head of the Committees, Dra. Andriana Anteng Anggorowati, M.Si and Sandy Budi Hartono, Ph.D as members of committees
- 3 Suryadi Ismadji, Ph.D as the Head of Chemical Engineering Process laboratory and Dra. Adriana Anteng Anggorowati, M.Si. as the Head of Chemical Analysis Laboratory
- 4 Mr. Novi as laborant of Chemical Engineering Process Laboratory, Mr. Pudjo as laborant of Chemical Engineering Operation Laboratory, and Mr. Agus as laborant of Chemicaal Analysis Laboratory.
- 5 Wenny Irawaty, Ph.D as Head of Chemical Engineering Department
- 6 Suryadi Ismadji, Ph.D as Dean of Engineering Faculty
- 7 Our parents and family who have given a lot of help and support, both materially and morally
- 8 Our lecturers, friends and also those who are too many to be listed by name that had contributed their kind assistance

The authors realize that this report is far from perfect, therefore any critics and comments which will better improve the research is gladly accepted. Lastly the authors hope that the report will be useful to all readers who need information regarding the research of the report.

Surabaya, May 26th 2016

The authors

CONTENTS

LETTER OF APPROVAL	ii
COPY RIGHT AGREEMENT	iv
LETTER OF DECLARATION	vi
PREFACE	viii
CONTENTS	x
LIST OF FIGURES.....	xii
LIST OF TABLES	xiii
ABSTRACT	xiv
CHAPTER I INTRODUCTION.....	1
I.1 Background.....	1
I.2 Objectives	3
I.3 Problem Limitation.....	3
CHAPTER II LITERATURE REVIEW	4
II.1. Nanocrystalline Cellulose	4
II.2. Lignocellulosic Materials	6
II.3. Cellulose.....	7
II.4. Hemicellulose	8
II.5. Lignin	9
II.6. Pre-treatment.....	9
II.7. Passion Fruit Peels Waste	10
II.8. Adsorption	11
II.9. Desorption	13
CHAPTER III EXPERIMENTAL METHOD	15
III.1. Experimental Design	15
III.2. Process Variable.....	20
III.3. Materials.....	22
III.4. Apparatus.....	23

III.5. Experimental Procedure.....	24
CHAPTER IV RESULT AND DISCUSSION.....	27
IV.1. Effect of Sulphuric Acid Concentration and Temperature to NCC Production.....	27
IV.2. Characterization of NCC	30
IV.3. Adsorption Kinetic Studies	34
IV.4. Desorption Kinetic Studies	36
IV.5. Adsorption Isotherm Studies.....	39
CHAPTER V CONCLUSION AND RECOMMENDATION	42
IV.1. Conclusion	42
IV.2. Recommendation.....	42
REFERENCES	43
APPENDIX A	
PRELIMINARY EXPERIMENT	48
APPENDIX B	
SOLUTION PREPARATION	53
APPENDIX C	
ADSORPTION AND DESORPTION PREPARATION	57
APPENDIX D	
CALCULATION OF ADSORPTION KINETIC DATA.....	59
APPENDIX E	
CALCULATION OF DESORPTION KINETIC DATA	62
APPENDIX F	
CALCULATION OF ADSORPTION ISOTHERM DATA.....	65

LIST OF FIGURES

Figure II.1.	The TEM Characteristic of the NCC	6
Figure II.2.	Lignocellulosic structure.....	7
Figure II.3.	Cellulose structure	8
Figure II.4.	Hemicellulose structure.....	8
Figure II.5.	Lignin structure	9
Figure III.1.	Flow diagram of NCC production	17
Figure III.2.	Flow diagram of adsorption and desorption kinetic of tetracycline antibiotic.....	18
Figure III.3.	Flow diagram of adsorption isotherm of tetracycline antibiotic	19
Figure IV.1.	Pareto chart of the standardized effect	28
Figure IV.2.	Interaction plot for yield of NCC.....	29
Figure IV.3.	TGA curve of (a) passion fruit peels waste and (b) pre-treated passion fruit peels waste.....	31
Figure IV.4.	XRD diffractogram of NCC.	32
Figure IV.5.	SEM picture of NCC.....	33
Figure IV.6.	Adsorption kinetic: Pseudo-first order.	35
Figure IV.7.	Adsorption kinetic: Pseudo-second order.....	35
Figure IV.8.	Desorption kinetic: Pseudo-first order.	37
Figure IV.9.	Desorption kinetic: Pseudo-second order.....	37
Figure IV.10.	Adsorption isotherm: Langmuir model.	39
Figure IV.11.	Adsorption isotherm: Freundlich model.....	40

LIST OF TABLES

Table II.1.	The advantages and disadvantages of NCC isolation methods.....	5
Table II.2.	Cellulose and lignin content in several biomass	7
Table II.3.	The contents of passion fruit peels waste	10
Table III.1.	Variables considered for DOE and their levels	16
Table IV.1.	The yield of NCC from passion fruit peels waste	28
Table IV.2.	DOE statistical analysis	29
Table IV.3.	Chemical composition of passion fruit peels waste and its pre-treated form	31
Table IV.4.	Fitted parameter of pseudo-first order and pseudo-second order for adsorption kinetic of tetracycline onto NCC	36
Table IV.5.	Fitted parameter of pseudo-first order and pseudo-second order for desorption kinetic of tetracycline from NCC	38
Table IV.6.	Fitted parameter of Langmuir and Freundlich equation for adsorption isotherm of tetracycline onto NCC	40

ABSTRACT

Nanocrystalline cellulose (NCC) is an advanced material which can be used in many applications, such as pharmaceutical, health, food, chemical, and etc. Because of that, NCC is very potential to be developed from many kinds of raw materials. In this research, passion fruit peels waste is used as the raw material of NCC production, because this raw material contains cellulose until 26.52% wt. Besides that, the use of this raw material is to decrease the need of woods, where the big need of woods will give damages to the environment. If the need of woods is big, the forest exploitation will increase significantly. Because of that, the industrial waste likes passion fruit peels waste is needed.

In this research, NCC was applied in drug delivery system, where NCC was used as the adsorbent of tetracycline antibiotic. NCC is used in this application because of its biodegradable and easy to modify characteristics. NCC can carry the tetracycline antibiotic to the target in human body, and release that drug. From this application, the efficiency and effectiveness of the drug activity will increase significantly.

This research is aimed to study the NCC production from passion fruit peels waste and the adsorption isotherm, the adsorption kinetic, and the desorption kinetic of tetracycline antibiotic by NCC. From this research, the data which was obtained are the yield percentage of NCC in various variables of NCC production and the best equations for the adsorption and desorption process in its various variables.

In this research, the best condition was obtained (based on highest yield of NCC, 2.86% wt.) using 52% wt. of sulphuric acid concentration at 50°C. The materials used and obtained in this research were analysed using TGA, XRD, and SEM. This NCC was suitable as drug carrier of tetracycline antibiotic. It was proofed from the adsorption and desorption mechanism. This material can adsorbed tetracycline antibiotic as much as 251.7667 mg/g using 500 ppm as tetracycline initial concentration in 60 minutes at 30°C. The adsorbed tetracycline was released slowly in 12 hours, where the desorption efficiency reached 90.51%.