

CONTENTS

	Page
Acknowledgement	d
Abstract in Thai	e
Abstract in English	g
List of Tables	l
List of Figures	n
List of Abbreviations	r
List of Symbols	s
Statement of Originality in Thai	t
Statement of Originality in English	u
Chapter 1 Introduction	1
1.1 Principle and Background	1
1.2 Objectives	6
1.3 Scopes of this study	6
Chapter 2 Theory	7
2.1 Lignocellulose	7
2.2 Purpose of lignocellulose material preparation	10
2.3 Lignocellulose pretreatment	11
2.4 Inhibitor	22
2.5 Lignin elimination from lignocellulose materials	26

Chapter 3 Literature Review	29
Chapter 4 Delignification of Bana Grass Using Alkaline and Ozone	42
4.1 Materials and methods	42
4.2 Condition for alkali pretreatment	43
4.3 Condition for ozone pretreatment	43
4.4 Results and Discussion	44
4.4.1 NaOH and Ozone Pretreatment	44
4.4.2 NH ₃ and Ozone Pretreatment	55
4.4.3 Ca(OH) ₂ and Ozone Pretreatment	64
4.5 Inhibitor examination	73
4.6 Mass flow diagram of ozonolysis	74
4.7 Conclusion	76
Chapter 5 Delignification of Corn Stover Using Alkaline and Ozone	77
5.1 Materials and methods	77
5.2 Condition for alkali pretreatment	78
5.3 Condition for ozone pretreatment	78
5.4 Results and Discussion	79
5.4.1 NaOH and Ozone Pretreatment	79
5.4.2 NH ₃ and Ozone Pretreatment	89
5.4.3 Ca(OH) ₂ and Ozone Pretreatment	97
5.5 Inhibitor examination	105
5.6 Conclusion	106
Chapter 6 Conclusions and Further works	107
6.1 Conclusions	107
6.2 Further works	110

References	111
Appendix	
Appendix A	116
Appendix B	130
Appendix C	146
Appendix D	153
Curriculum Vitae	155



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

LIST OF TABLES

	Page
Table 2.1 Comparison strengths/weaknesses of any pretreatments process	20
Table 2.2 Results of pretreatment for structure in Lignocellulose materials	21
Table 2.3 Origin of inhibited substances and the highest concentration that was accepted in Ethanol fermented conditions	24
Table 2.4 compared any process of Lignocellulose materials pretreatment that effect to inhibited substances	25
Table 2.5 Lignocellulose materials pretreatment by alkaline method effects to lignin number reduction	27
Table 2.6 Lignocellulose materials pretreatment by ozone method effects lignin number reducing	27
Table 2.7 Shows lignocellulose materials pretreatment by organic solvent method effects lignin number reduction	28
Table 4.1 Characterization of untreated and pretreated materials with NaOH solutions pretreatment	47
Table 4.2 Major compositions of untreated and pretreated materials with ozonolysis process	52
Table 4.3 Characterization of NaOH solution pretreated materials with ozonolysis process	53
Table 4.4 Characterization of untreated and pretreated materials with NH ₃ solution pretreatment	58
Table 4.5 Characterization of NH ₃ solution pretreated materials with ozonolysis process	62
Table 4.6 Characterization of untreated and pretreated materials with Ca(OH) ₂ solution pretreatment	67
Table 4.7 Characterization of Ca(OH) ₂ solution pretreated materials with ozonolysis process	71
Table 4.8 Result of Acetaldehyde analysis	73

Table 4.9 Result of Total phenolic analysis	73
Table 4.10 Mass flow data ozonolysis	75
Table 5.1 Characterization of untreated and pretreated materials with NaOH solutions pretreatment	82
Table 5.2 Major compositions of untreated and pretreated materials with ozonolysis process	86
Table 5.3 Characterization of NaOH solution pretreated materials with ozonolysis process	87
Table 5.4 Characterization of untreated and pretreated materials with NH ₃ solution pretreatment	91
Table 5.5 Characterization of NH ₃ solution pretreated materials with ozonolysis process	95
Table 5.6 Characterization of untreated and pretreated materials with Ca(OH) ₂ solution pretreatment	99
Table 5.7 Characterization of Ca(OH) ₂ solution pretreated materials with ozonolysis process	103
Table 5.8 Result of Acetaldehyde analysis	105
Table 5.9 Result of Total phenolic analysis	105

LIST OF FIGURES

	Page
Figure 2.1 Structure of cellulose	7
Figure 2.2 Hemicellulose structure	8
Figure 2.3 Lignin structure	9
Figure 2.4 Lignocellulose materials pretreatment	9
Figure 2.5 Forming between ozone and lignin molecule	17
Figure 2.6 Inhibitor types and chemical structures	22
Figure 4.1 The ozonolysis treatment apparatus	44
Figure 4.2 ECONOWATT model OZG	44
Figure 4.3 Remaining composition in NaOH solution with 1 hr pretreatment	48
Figure 4.4 Remaining composition in NaOH solution with 2 hrs pretreatment	49
Figure 4.5 Remaining composition in NaOH solution with 3 hrs pretreatment	49
Figure 4.6 Effect of pretreatment time of NaOH solution	50
Figure 4.7 shows weight percent of remaining cellulose and lignin removal based on untreated material	50
Figure 4.8 presents the ratio of cellulose and lignin for NaOH solution pretreatment	51
Figure 4.9 shows the composition of NaOH solution pretreatment matter with ozone	54
Figure 4.10 compares the ratio of cellulose to lignin of material with ozone pretreatment of untreated and NaOH solution pretreatment	54
Figure 4.11 Remaining composition in NH ₃ solution with 12 hrs pretreated material.	59
Figure 4.12 Remaining composition in NH ₃ solution with 24 hrs pretreated material	59
Figure 4.13 Remaining composition in NH ₃ solution with 36 hrs. pretreated material	60
Figure 4.14 Effect of pretreatment time of NH ₃ solution	60
Figure 4.15 shows weight percent of cellulose remaining and lignin removal based on an untreated material	61

Figure 4.16 presents the ratio of cellulose to lignin for NH ₃ solution pretreatment	61
Figure 4.17 shows the composition of NH ₃ solution pretreatment matter with ozone	63
Figure 4.18 compare the ratio of cellulose to lignin of material with ozone pretreatment of untreated and NH ₃ solution pretreatment	63
Figure 4.19 Remaining composition in Ca(OH) ₂ solution with 12 hrs pretreated material	68
Figure 4.20 Remaining composition in Ca(OH) ₂ solution with 24 hr pretreated material	68
Figure 4.21 Remaining composition in Ca(OH) ₂ solution with 36 hrs. pretreated material	69
Figure 4.22 Effect of pretreatment time of Ca(OH) ₂ solution	69
Figure 4.23 shows weight percent of cellulose remaining and lignin removal based on an untreated material	70
Figure 4.24 presents the ratio of cellulose to lignin for Ca(OH) ₂ solution pretreatment	70
Figure 4.25 shows the composition of Ca(OH) ₂ solution pretreatment matter with ozone	72
Figure 4.26 compare the ratio of cellulose to lignin of material with ozone pretreatment of untreated and Ca(OH) ₂ solution pretreatment	72
Figure 4.27 The ozonolysis treatment and ozone analysis apparatus	75
Figure 4.28 Mass flow diagram ozonolysis of 10 min.	75
Figure 4.29 Mass flow diagram ozonolysis of 20 min.	75
Figure 4.30 Mass flow diagram ozonolysis of 30 min.	76
Figure 5.1 The ozonolysis treatment apparatus	79
Figure 5.2 ECONOWATT model OZG	79
Figure 5.3 Remaining composition in NaOH solution with 1 hr pretreatment	83
Figure 5.4 Remaining composition in NaOH solution with 2 hrs pretreatment	83
Figure 5.5 Remaining composition in NaOH solution with 3 hrs pretreatment	84
Figure 5.6 Effect of pretreatment time of NaOH solution	84
Figure 5.7 shows weight percent of remaining cellulose and lignin removal based on untreated material	85

Figure 5.8 presents the ratio of cellulose and lignin for NaOH solution pretreatment	85
Figure 5.9 shows the composition of NaOH solution pretreatment matter with ozone	88
Figure 5.10 compares the ratio of cellulose to lignin of material with ozone pretreatment of untreated and NaOH solution pretreatment	88
Figure 5.11 Remaining composition in NH ₃ solution with 12 hrs pretreated material.	92
Figure 5.12 Remaining composition in NH ₃ solution with 24 hrs pretreated material	92
Figure 5.13 Remaining composition in NH ₃ solution with 36 hrs. pretreated material	93
Figure 5.14 Effect of pretreatment time of NH ₃ solution	93
Figure 5.15 shows weight percent of cellulose remaining and lignin removal based on an untreated material	94
Figure 5.16 presents the ratio of cellulose to lignin for NH ₃ solution pretreatment	94
Figure 5.17 shows the composition of NH ₃ solution pretreatment matter with ozone	96
Figure 5.18 compare the ratio of cellulose to lignin of material with ozone pretreatment of untreated and NH ₃ solution pretreatment	96
Figure 5.19 Remaining composition in Ca(OH) ₂ solution with 12 hrs pretreated material	100
Figure 5.20 Remaining composition in Ca(OH) ₂ solution with 24 hr pretreated material	100
Figure 5.21 Remaining composition in Ca(OH) ₂ solution with 36 hrs. pretreated material	101
Figure 5.22 Effect of pretreatment time of Ca(OH) ₂ solution	101
Figure 5.23 shows weight percent of cellulose remaining and lignin removal based on an untreated material	102
Figure 5.24 presents the ratio of cellulose to lignin for Ca(OH) ₂ solution Pretreatment	102

Figure 5.25 shows the composition of $\text{Ca}(\text{OH})_2$ solution pretreatment matter with ozone 104

Figure 5.26 compare the ratio of cellulose to lignin of material with ozone pretreatment of untreated and $\text{Ca}(\text{OH})_2$ solution pretreatment 104



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

LIST OF ABBREVIATIONS

mg	Milligram
g	Gram
kg	Kilogram
nm	Nanometer
mm	Millimeter
cm	Centimeter
m	Meter
m ²	Square meter
m ³	Cubic meter
o.d.	Outside diameter
ml	Milliliter
l	Liter
μl	Microliter
μl/g	Microliter per gram
g/l	Gram per liter
w/w	Weight by weight
w/v	Weight by volume
min	Minute
hr	Hour
MPa	Megapascal
psi	Pounds per square inch
FPU	Filter paper unit
rpm	Revolutions per minute
NGV	Natural Gas for Vehicle
TAPPI	Technical Association of the Pulp and Paper Industry
AFEX	Ammonia fibre explosion
NMR	Nuclear Magnetic Resonance Spectroscopy

LIST OF SYMBOLS

α	Alpha
β	Beta
γ	Gamma
μ	Micro
%	Percentile
$^{\circ}\text{C}$	Degree Celsius
pH	Potential of Hydrogen ion
N	Normality
M	Molarity
CO_2	Carbon dioxide
NaOH	Sodium hydroxide
NH_3	Ammonia
NH_4OH	Ammonium hydroxide
$\text{Ca}(\text{OH})_2$	Calcium hydroxide
HCl	Hydrochloric acid
H_2SO_4	Sulfuric acid
KOH	Potassium hydroxide
$\text{Li}(\text{OH})_2$	Lithium hydroxide
O_3	Ozone
OH°	Hydroxyl radical
OH^-	Hydroxide ion
O_2^-	Super oxide
M_w	Weight-average molecular weight
M_z	Z-average molecular weight
M_n	Number-average molecular weight

ข้อความแห่งการริเริ่ม

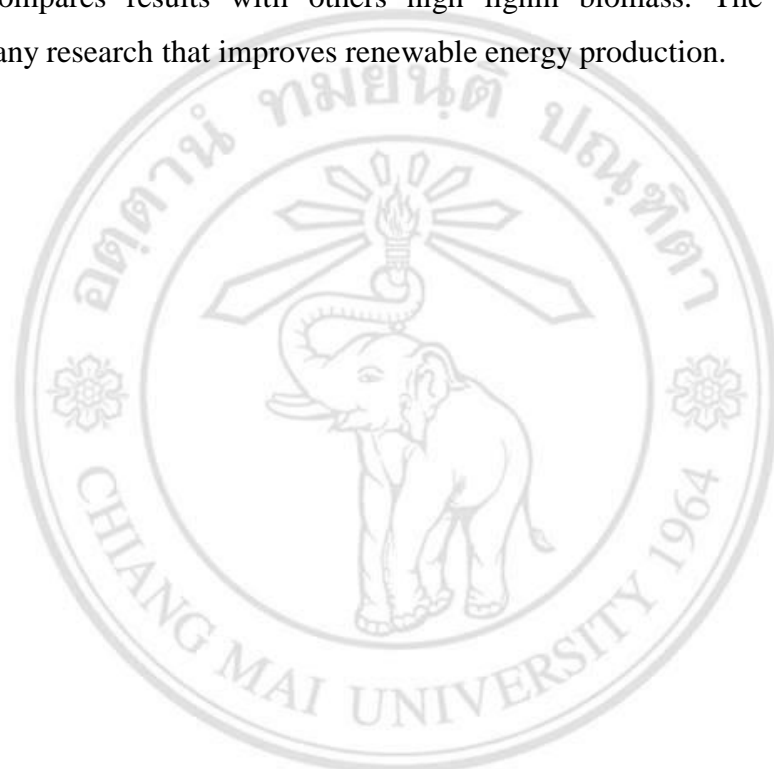
คุณฉันทิพนธ์นี้ได้ศึกษาการปรับสภาพวัสดุทิกโนเซลลูโลสจากหญ้าขนาน่า เพื่อการจัดถักนินโดยการ
ใช้ฮัลคาไลน์ร่วมกับไอโซน นอกจากนี้ได้ทำการเปรียบเทียบกับชีวมวลที่มีปริมาณลิกนินสูง
ข้อมูลที่ได้จะเป็นข้อมูลพื้นฐานในการวิจัยสำหรับการผลิตพลังงานทดแทนของประเทศต่อไป



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

STATEMENT OF ORIGINALITY

The thesis proposes the method to pretreat lignocellulose from Bana grass. The propose method is a combination of alkaline and ozone for delignification. This study also compares results with others high lignin biomass. The result makes advantage to any research that improves renewable energy production.



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved