PROPERTIES OF GREEN PARTICLEBOARD MADE WITH CITRIC ACID, FURFURYL ALCOHOL AND PALM OIL

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PROPERTIES OF GREEN PARTICLEBOARD MADE WITH CITRIC ACID, FURFURYL ALCOHOL AND PALM OIL

By

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A Project Report Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Wood Science and Technology in the Faculty of Forestry
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DEDICATION

Wholeheartedly dedicate this research

To my beloved parents and siblings.

To all my beloved course mates and friends,

Thank you for all your encouragements and supports.

ABSTRACT

The diversification of the production of wood panel products such as particleboards is crucial as it affects the wood industry and furniture industry in terms of their operations. The consumption of UF has increased gradually and has been widely utilized for producing wood composites recently. As the awareness of society towards the environmental and human health issues is in demand, thus it is important to create a particleboard with natural binding agent in order to substitute the use of UF which acts as the main adhesives in the boards. The aims of this study were proposed to produce green particleboard with very low formaldehyde emission, good biological durability and acceptable physical properties. Subsequent to this, the physical properties such as thickness swelling and water absorption of the particleboard bonded with citric acid were determined. Also, the biological durability against white rot fungi and subterranean termites of the particleboard bonded with citric acid were investigated and the formaldehyde emission from particleboard bonded with citric acid was evaluated. In this study, it is proven that the production of particleboard bonded citric acid with the addition of 20% palm oil and 20% furfuryl alcohol could act as the green binder for substituting UF. Furthermore, the citric acid which is known as the main material of wood adhesive has been justified and examined throughout a series of properties evaluation.

ABSTRAK

Kepelbagaian dalam pengeluaran produk panel kayu seperti papan partikel adalah penting kerana ia mempengaruhi industri kayu dan industri perabot dari segi operasi. Penggunaan UF telah meningkat dan digunakan secara meluas untuk menghasilkan komposit kebelakangan ini. Memandangkan kesedaran masyarakat terhadap isu-isu alam sekitar dan kesihatan semakin meningkat, penghasilan papan partikel menggunakan perekat semulajadi adalah amat penting untuk menggantikan penggunaan UF yang bertindak sebagai perekat utama dalam penghasilan papan. Tujuan kajian ini dijalankan adalah untuk menghasilkan papan partikel yang mesra alam dengan pembebasan formaldehid yang sangat rendah, ketahanan biologi yang baik dan ciri-ciri fizikal yang boleh diterima. Dengan ini, ciri-ciri fizikal seperti pengembangan ketebalan dan penyerapan air dalam papan partikel yang menggunakan perekat asid sitrik telah dikenalpasti. Selain itu, ketahanan biologi terhadap kulat reput putih dan rayap bawah tanah daripada papan partikel yang dibuat menggunakan asid sitrik telah diselidik dan pembebasan formaldehid daripada papan partikel tersebut telah dinilai. Dalam kajian ini, telah dibuktikan bahawa penambahan 20% minyak kelapa sawit dan 20% furfuril alkohol ke dalam perekat asid sitrik dalam penghasilan papan partikel boleh dijadikan perekat semulajadi untuk menggantikan UF. Tambahan pula, asid sitrik yang dikenali sebagai bahan utama perekat kayu telah dijustifikasi dan diperiksa melalui penilaian sifat.

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This research stands as a testament to their unconditional love and encouragement. Thank you all for playing such important roles along this journey.

APPROVAL SHEET

I certify that this research project report entitled “Properties of Green Particleboard made with Citric Acid, Furfuryl Alcohol and Palm Oil” by Cher Jia Dong has been examined and approved as a partial fulfillment of the requirements for the degree of Bachelor of Wood Science and Technology in the Faculty of Forestry, Universiti Putra Malaysia

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TABLE OF CONTENTS

	Page
DEDICATION	i
ABSTRACT	ii
ABSTRAK	iii
ACKNOWLEDGEMENTS	iv
APPROVAL SHEET	v
TABLE OF CONTENTS	vi
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF ABBREVIATION	x
CHAPTER	
1 INTRODUCTION	
1.1 Background	1
1.2 Problem Statement and Justification	2
1.3 Objectives	4
2 LITERATURE REVIEW	
2.1 Emission of Formaldehyde from Urea Formaldehyde (UF)	6
2.2 Application of Citric Acid (CA) as Natural Adhesive	7
2.3 Application of Furfuryl Alcohol (FA) in Wood	8
2.4 Exportation and Importation of Particleboard	10
2.5 Current Market of Major Wood-based Products	11
3 METHODOLOGY	
3.1 Materials	14
3.1.1 Rubberwood (RW) Particles	14
3.1.2 Urea Formaldehyde (UF)	14
3.1.3 Citric Acid (CA)	14
3.1.4 Furfuryl Alcohol (FA)	15
3.1.5 Palm Oil (PO)	15
3.2 Apparatus	15
3.3 Methods	15
3.3.1 Preparation of Binding Agents	15
3.3.2 Production of Particleboard	16
3.4 Properties Evaluation	18
3.4.1 Thickness Swelling (TS) Test	18
3.4.2 Water Absorption (WA) Test	18
3.4.3 Decay Resistance Test	19
3.4.4 Termite Resistance Test	20
3.4.5 Formaldehyde Emission Test (Desiccator method)	21
3.5 Interpretation of Data	24

4 RESULTS AND DISCUSSION
4.1 Summary of analysis of variance (ANOVA) at P ≤ 0.05 of the interaction between treatment and properties of particleboard 25
4.2 Thickness Swelling (TS) 26
4.3 Water Absorption (WA) 29
4.4 Decay Resistance 32
4.5 Termite Resistance 37
4.6 Formaldehyde Emission 40

5 CONCLUSION AND RECOMMENDATIONS
5.1 Conclusion 42
5.2 Recommendation 43

REFERENCES 44
APPENDIX A 49
PUBLICATION OF THE PROJECT UNDERTAKING 51

LIST OF TABLES

		Page
Table 4.1	ANOVA table of Thickness Swelling (TS), Water Absorption (WA), Decay Resistance and Termite Resistance	25
Table 4.2	Thickness swelling (TS) of the samples after 2 hours and 24 hours immersion in water	26
Table 4.3	Water absorption (WA) of the samples after 2 hours and 24 hours immersion in water	30
Table 4.4	Weight loss (WL) of samples after exposed to *Pycnoporus sanguineus*	34
Table 4.5	Weight loss (WL) of samples after exposed to *Coptotermus curvignathus*	38
Table 4.6	Formaldehyde emission of particleboard made from different binding agents	41

LIST OF FIGURES

		Page
Figure 2.1	Chart of Malaysia's Exports: Annual: Timber: MTIB: SK: Particleboard from 1994 to 2017	11
Figure 3.1	Experimental procedures: Flow chart of preparing binding agents and producing particleboard	16
Figure 3.2	Experimental design of study	17
Figure 3.3	Testing of Formaldehyde Emission by Desiccator Method	22
Figure 4.1	Thickness swelling (TS) of the samples after 2 hours and 24 hours immersion in water	27
Figure 4.2	Water absorption (WA) of the samples after 2 hours and 24 hours immersion in water	30
Figure 4.3	Visual appearance of particleboards bonded with different binding agents after exposure to *Pycnoporus sanguineus*: (a) 10% UF; (b) 10% UF + 20% PO; (c) 15% CA and (d) 15% CA + 20% PO + 20% FA	33
Figure 4.4	Weight loss (WL) of samples after exposed to *Pycnoporus sanguineus*	34
Figure 4.5	Visual appearance of particleboards bonded with different binding agents after exposure to *Coptotermus curvignathus*: (a) 10% UF; (b) 10% UF + 20% PO; (c) 15% CA and (d) 15% CA + 20% PO + 20% FA	37
Figure 4.6	Weight loss (WL) of samples after exposed to *Coptotermus curvignathus*	39

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASE	Anti-swelling Efficiency
ASTM	American Society for Testing and Materials
CA	Citric Acid
CAGR	Compound Annual Growth Rate
DDL	Diacetyl dihydro lutidine
FA	Furfurly Alcohol
FTIR	Fourier-Transform Infrared Spectroscopy
HDF	High Density Fiberboard
HSD	Tukey's Honest Significant Difference Test
IB	Internal Bonding
JIS	Japanese Industrial Standards
MDF	Medium-density Fiberboard
MN	Million
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
MTIB	Malaysian Timber Industry Board
MUF	Melamine-Urea-Formaldehyde
MYR	Malaysian Ringgit
OSB	Oriented Strand Board
PO	Palm Oil
PF	Phenol Formaldehyde
R&D	Research and Development

RW	Rubberwood
SAS	Statistical Analysis System
TS	Thickness Swelling
UF	Urea Formaldehyde
USD	United States Dollar
WA	Water Absorption
WL	Weight Loss
WPG	Weight Percent Gain
WT	Weight

CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, the industry has gradually expanded into the production of high value-added reconstituted panel products such as particleboard and medium density fiberboard in order to maximize the utilization of wood resources. The particleboard industry has currently grown into 32 mills in operation as well. Over the years, the industry has successfully exported its products particularly for use in the furniture industry (Ministry of International Trade and Timber Industry, 2015).

Sellers Jr (2001) claims that worldwide wood adhesive consumption is 13.3 million tons and has already reached a total sale value of more than $6 billion in the early of this decade. Currently, a confirmation is made by Bono et al. (2006, 2007, and 2008) through the review on the usage of formaldehyde-based adhesives. Phenol-Formaldehyde (PF), Urea-Formaldehyde (UF) and Melamine-Urea-Formaldehyde (MUF) resins will be used as dominant adhesives for production of wood composites.

According to research that is proposed by Conner (1996), urea formaldehyde resins are used as a major adhesive by the forest products industry. This is due to a number of benefits, including low cost, ease of use under a wide variety of curing conditions, low cure temperatures, water solubility, resistance to microorganisms and to abrasion, hardness, excellent thermal properties, and lack of color, especially of the cured resin. The major disadvantage of urea formaldehyde adhesives as compared with other thermosetting wood adhesives, such as phenol-formaldehyde and polymeric diisocyanates, is the lack of resistance to moist conditions, especially in combination with heat. These conditions lead to a reversal of the bond-forming reactions and the release of formaldehyde. For this reason, urea formaldehyde resins are usually used for the manufacture of products intended for interior use only.

However, even when it is used for interior purposes, the slow release of formaldehyde (a suspected carcinogen) from products bonded with urea formaldehyde adhesives is still a major concern in terms of environmental and human health issues in society nowadays. Therefore, this creates a strong demand for sustainable products, such as natural wood adhesives.

1.2 Problem Statement and Justification

The majority of adhesives used in particleboard manufacturing are synthetic and mainly formaldehyde-based resin especially urea formaldehyde (UF) which has high reactivity, good binding strength and low cost. However, they tend to release a small amount of formaldehyde, a toxic chemical compound obtained from non-renewable resources and classified as human carcinogen, which raises public concern (Ferreira et al., 2018). Also, the declination of non-renewable fossil resources is anticipated to restrict the usage of conventional synthetic resins in the near future. Therefore, the development of natural adhesives derived from renewable non-fossil resources is very important for the future.

Natural adhesive that can produce excellent bonding performance are favorable. On account to that, citric acid, also called 2-hydroxy-1, 2, 3-propanetricarboxylic acid, has potential to be applied as binding agent to improve the properties of agricultural residue particleboard. Citric acid is a green material widely used in foods, beverages, and pharmaceuticals. Citric acid is an organic polycarboxylic acid containing three carboxyl groups and is used as cross-linking agent to enhance the properties of wood. In addition, it has been reported as a cross-linking agent to improve the physical and mechanical properties of wood, plant fiber, paper, and starch. However, the application of citric acid as a main material of wood adhesive has received limited attention (Umemura et al., 2013). Therefore, the possibility of citric acid as a natural adhesive for wood composite is further investigated in this study.

Previous study shows that the particleboard bonded with citric acid alone has inferior physical properties compared to that of the UF-bonded particleboard. Therefore, green materials such as furfuryl alcohol and palm oil can be added into the citric acid to impart better dimensional stability to the particleboard. Furfuryl alcohol is environmentally friendly chemical in which ecotoxicological studies of furfurylated wood and leachates from furfurylated wood has shown no significant ecotoxicity. As proposed by Schneider et al. (2009), furfuryl alcohol is known as a multi-functional polymer with a high possibility of polymerization and crosslinking. The alcohol groups of furfuryl alcohol are reported to be reactable and the rings within the polymers can be opened for further reaction. Due to this reason, the introduction of furfuryl alcohol can reduce the hygroscopicity of the wood samples and resulted in better mechanical properties than in raw wood.

Besides, furfuryl alcohol is manufactured industrially by hydrogenation of furfural, which is itself typically produced from waste bio-mass such as corncobs or sugar cane bagasse. Therefore, it is confirmed that furfuryl alcohol itself is a green chemical. As one of the biggest producers in the world, palm oil is readily available in Malaysia. Vegetable oils such as linseed and rapeseed oils, as well as palm oil are green materials that are safe to the environment and has long been used in the wood protection treatment. Apart from that, application of palm oil is able to substitute wax emulsion, non-green petroleum-based materials and to impart better dimensional stability to particleboard.

1.3 Objectives

The main objective of this study is to produce green particleboard with very low formaldehyde emission, good biological durability and acceptable physical properties.

The specific objectives for this study are:

i) To determine the physical properties such as thickness swelling and water absorption of the particleboard bonded with citric acid

ii) To investigate the biological durability against white rot fungi and subterranean termites of the particleboard bonded with citric acid

iii) To determine the formaldehyde emission from particleboard bonded with citric acid

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