PHYSICO-MECHANICAL AND BIOLOGICAL PROPERTIES OF RUBBERWOOD PARTICLEBOARD BONDED WITH CITRIC ACID

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By

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DEDICATION

Especially dedicated to

My beloved Parent,

“Norazaliah binti Abu Samah”

Sister,

“Siti Nurul Ashikin binti Rosli”

And,

All my beloved Coursemates…

ABSTRACT

Particleboard is one the major timber products in Malaysia which generates the economy and exportation value. The usage of conventional synthetic resins would be restricted in the future due to depleting non-renewable fossil resources and the applications of renewable bio-based resins are therefore inevitable. Citric acid is one of a potential chemical that has good adhesion property for wood. The utilization of this chemical to replace urea formaldehyde resin in particleboard production could eliminate the problem of formaldehyde emission. The aim of this study is to determine the suitability of using citric acid to replace urea formaldehyde (UF) as binding agent in particleboard production. The performances of citric acid bonded-particleboard evaluated were physical, mechanical properties and its resistance against fungal decay and termite attacks. Particleboard bonded with citric acid met the standard requirement of water absorption, thickness swelling and internal bonding, however, the modulus of rupture (MOR) and modulus of elasticity (MOE) in static bending did not surpass the standard requirement. When compared to UF-bonded particleboard, the performance in terms of dimensional stability and mechanical properties of citric acid particleboard are significantly lower. As regards to biological properties, the citric acid-bonded boards had higher resistance towards white rot fungus and termites than urea-formaldehyde bonded boards.

ABSTRAK

Papan partikel adalah salah satu produk kayu utama di Malaysia yang menjana ekonomi dan nilai eksport. Penggunaan perekat sintetik konvensional akan dihadkan pada masa depan disebabkan oleh kekurangan sumber fosil yang tidak boleh diperbaharui dan penggunaan perekat berasaskan bio yang boleh diperbaharui oleh itu tidak dapat dielakkan. Asid sitrik adalah salah satu bahan kimia yang berpotensi yang mempunyai sifat lekatan yang baik untuk kayu. Penggunaan bahan kimia ini untuk menggantikan perekat urea formaldehida dalam pengeluaran papan partikel boleh mengelakkan masalah pelepasan formaldehid. Tujuan kajian ini adalah untuk menentukan kesesuaian menggunakan asid sitrik untuk menggantikan urea formaldehyde (UF) sebagai agen mengikat dalam pengeluaran partikel. Prestasi papan zarah terikat asid sitrik yang dinilai adalah sifat fizikal, mekanikal dan rintangannya terhadap kerosakan kulat dan serangan anai-anai. Papan zarah yang terikat dengan asid sitrik mencapai keperluan standard penyerapan air, ketebalan bengkak dan ikatan dalaman, bagaimanapun, modulus pecah (MOR) dan modulus keanjalan (MOE) dalam lenturan statik tidak melebihi keperluan standard. Apabila dibandingkan dengan papan zarah terikat UF, prestasi dari segi kestabilan dimensi dan sifat mekanik papan partikel asid sitrik jauh lebih rendah. Berkenaan dengan sifat biologi, papan terikat asid sitrik mempunyai ketahanan yang lebih tinggi ke arah jamur dan rayutan rot dari urea formaldehid bonded boards.

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APPROVAL SHEET

I certify that this research project report entitled “Physico-Mechanical and Biological Properties of Rubberwood Particleboard Bonded with Citric acid” by Mohd Ashraaf bin Rosli 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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CHAPTER 1

INTRODUCTION

1.1 Background

With the recent rapid increase in wood composite production worldwide, the total consumption of wood adhesives has greatly increased. Formaldehyde-based resins, such as urea-formaldehyde, phenol-formaldehyde and melamine formaldehyde, are still the main adhesives used. However, formaldehyde emission from these adhesives is a major concern. Moreover, production of these resins depends on the petroleum industry. Owing to limited petroleum resources, strict legislation and environmental concerns, there is increasing interest in developing environmental friendly adhesives from renewable natural resources. Therefore, this research aim to introduce citric acid as a binder to replace the petroleum based adhesive.

Application of citric acid as a binder is a new finding in wood technologies where it still under the R&D in a few countries such as China and a few countries that a few more step ahead Malaysia in wood technologies. Citric Acid is an acid that usually can be found in fruit and plant that have properties that are sticky. Citric acid is a weak organic acid that has the chemical formula $C_6H_8O_7$ (Figure 1.1). It occurs naturally in citrus fruits. Citric acid also an acid that give no harm to human and this is proven by it has been used as a flavoring and preservative in food and beverage. The properties have led researcher to test whether the citric acid can stand alone as a binder to replace the petroleum based binder. The

source of citric acid can be obtained from natural source so that it have completing the need of this research which to reduce the dangerous chemical emission.

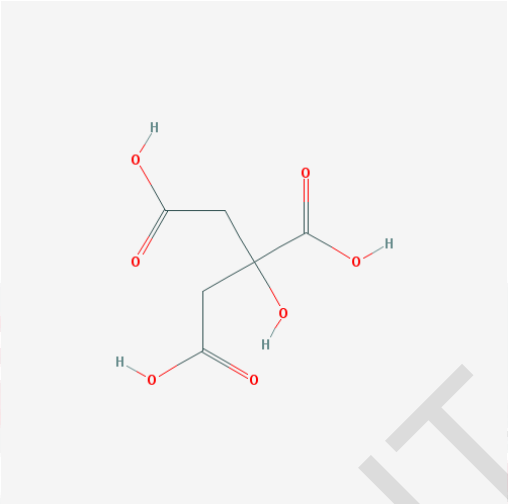

Figure 1.1 Chemical structure of citric acid

Rubber wood timber is a cheap source of raw material. In 1990s, rubber wood timber comprised more than 70-80% of the wooden furniture produced in Malaysia due to its light colour, smooth surface texture, attractive appearance and light in weight. This resulted in increasing demand for rubber wood timber as raw material for local wooden furniture making industry. However, demand of rubber wood increase cause rubber wood face shortage problem. Figure 1.2 shows the planted area of rubber declined from 123.78 thousand ha in 2000 to 53.35 thousand ha in 2000. It is then slightly increase to 92.12 thousand ha in 2008.

Year	Malaysia Total ('000 ha)		
	Estate	Smallholding	Malaysia
2000	123.78	1,306.90	1,430.68
2001	95.52	1,293.80	1,389.32
2002	84.81	1,264.00	1,348.81
2003	78.46	1,247.14	1,325.60
2004	64.42	1,214.41	1,278.83
2005	57.37	1,213.93	1,271.30
2006	54.15	1,209.44	1,263.59
2007	53.35	1,194.69	1,248.04
2008	61.10	1,185.93	1,247.03
2009	61.10	967.14	1,028.24
2010	64.20	956.18	1,020.38
2011	64.20	962.84	1,027.04
2012	65.94	975.25	1,041.19
2013	77.41	979.86	1,057.27
2014	80.12	985.51	1,065.63
2015[e]	86.12	992.51	1,078.63
2016[f]	92.12	999.51	1,091.63

Figure 1.2 : Statistic of Malaysia's Rubber Planted Hectare by Sector

1.2. Statement of Problem

The development of natural adhesives derived from non-fossil resources is very important for the future. Besides, it is desirable to be safe adhesives without using harmful chemical substances. As the most commercially important aldehyde, 70% of world consumption of formaldehyde has been used solely for the production of amino-based resins such as urea-, phenol-, and melamine-formaldehyde resins (UF, PF, and MF resins). These resins are mainly used for the fabrication of fibrous and granular boards such as particleboard and medium density fiberboard, plywood and molding compounds. Many researches have been carried out to investigate ways of reducing the utilization of the synthetic adhesives. The purpose of this modification technique is to reduce the dangerous emission that produced by the petroleum based adhesive.

However, declining of non-renewable fossil resources is anticipated to restrict the usage of conventional synthetic resins in the near future. Application of bio-based resins such as lignin, tannin and protein are recommended but the bonding of the resultant panels is poor. Therefore, focus should be put on using a natural adhesive that can produce excellent bonding performance. On account to that, citric acid, also called 2-hydroxy-1,2,3-propanetricarboxylic acid, is potentially to be applied as binding agent to improve the properties of agricultural residue particleboard. Citric acid is an organic polycarboxylic acid containing three carboxyl groups and was used as cross-linking agent to enhance the properties of wood. Nevertheless, studies on application of citric acid as binding agents for particleboard are very limited. Therefore, to solve the problem facing by particleboards, this study aims to assess the properties of particleboard fabricated from rubber wood bonded with citric acid.

In this study, application of citric acid as a natural adhesive for particleboard was tested. Few properties such as mechanical strength, dimensional stability, chemical content and biological durability of the particleboard bonded with citric acid were examined.

1.3 Objectives

The objectives of this study are to:

i. To assess the physic-mechanical and biological properties of particleboard made from rubber wood particles bonded with citric acid.

ii. To compare the properties of the citric acid-bonded particleboard with the particleboard made from conventional urea formaldehyde resin.

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