



UNIVERSITI PUTRA MALAYSIA

TANNIN-FURFURYL ALCOHOL ADHESIVE FOR PARTICLEBOARD

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TANNIN-FURFURYL ALCOHOL ADHESIVE FOR PARTICLEBOARD



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for the Degree of Bachelor of Wood Science Technology in the
Faculty of Forestry
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DEDICATION

I dedicate my thesis to my family and friends. A special feeling of gratitude to my loving parents, Rosli bin Abdul Rahman and Junaidah binti Che Kar whose words of encouragement and push for tenacity ring in my ears. To my siblings, Hanis Hanafi, Harnani Hazwani and Haris Hazli who have never left my side and are very special. Without their blessing and support, this whole project would not be possible.



ABSTRACT

Acacia (Acacia mangium) is a fast growing species that dominate the plantation in Malaysia that have potential to partially replace phenol. Thus, with the fast maturing *Acacia* plantation in this country, there is urgency to find the best way to utilize this timber resource. Polyphenolic structure that contain in *A. mangium* tannin, has potential to be used as a good bonding agent. In this study, the tannin solution with 30%± solid content was extracted from *Acacia* bark. The aim of this study was to determine the physical and mechanical properties of the particleboard made from Tannin-furfuryl alcohol (TFA). The tannin was mixed with furfuryl alcohol (FA) at two ratio of tannin and PF (4:1 and 3:1) were used as variable with fixed value at pH 10. Then, a duplicate of laboratory particleboards were made by using Urea Formaldehyde (UF) and TFA resin as a binder. The physical and mechanical properties of particleboard were tested according to EN 312 1995 and BS EN 317 1993 for modulus of rupture, modulus of elasticity, internal bonding test, thickness swelling and water absorption respectively. The result shows that the IB strength for particleboard from TFA 4:1 and 3:1 were 0.34 and 0.25 N/mm², respectively. While the particleboard from UF resin was 0.47 N/mm².

ABSTRAK

Akasia (*Acacia mangium*) adalah spesies yang berkembang pesat yang menguasai perladangan di Malaysia yang berpotensi untuk menggantikan fenol. Maka, dengan sifat cepat matang Akasia di negara ini, adalah penting untuk mencari jalan terbaik menggunakan sumber balak ini. Struktur polifenolik yang terdapat di dalam tanin, ia mempunyai potensi untuk digunakan sebagai ejen pengikat yang baik. Dalam kajian ini, 30%± kandungan pepejal larutan tanin yang telah diekstrak daripada kulit kayu Akasia. Tujuan kajian ini adalah untuk menentukan sifat-sifat fizikal dan mekanikal papan serpai yang dibuat dari Tannin-furfuryl alkohol (TFA). Tanin dicampurkan dengan furfuryl alkohol (FA) dengan dua nisbah tanin dan PF (4: 1 dan 3: 1) digunakan sebagai pembolehubah dengan nilai tetap pada pH 10. Kemudian, duplikat papan serpai makmal telah dibuat dengan menggunakan Urea Formaldehyde (UF) dan TFA resin sebagai pengikat. Sifat-sifat fizikal dan mekanikal papan serpai diuji mengikut EN 312 1995 dan BS EN 317 1993. Keputusan menunjukkan kekuatan ikatan dalaman bagi papan serpai bagi resin TFA 4:1 dan 3:1 adalah 0.34 dan 0.25 N/mm². Manakala, papan serpai dari resin UF ialah 0.47 N/mm².

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APPROVAL SHEET

I certify that this research project report entitled “Tannin-furfuryl Alcohol Adhesive for Particleboard” has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Wood Science Technology in the Faculty of Forestry, Universiti Putra Malaysia.

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LIST OF ABBREVIATIONS

TFA	Tannin Furfuryl Alcohol
UF	Urea Formaldehyde
PF	Phenol Formaldehyde
FA	Furfuryl Alcohol
MC	Moisture Content
TS	Thickness Swelling
WA	Water Absorption
MOR	Modulus of Rupture
MOE	Modulus of Elasticity
IB	Internal Bond
Na₂SO₃	Sodium Sulphate
Na₂CO₃	Sodium Carbonate
ANOVA	Analysis of Variance

CHAPTER 1

INTRODUCTION

1.1 Background

Acacia mangium has been planted extensively in Peninsular Malaysia according to Forest Research Institute Malaysia. Hence, large quantities of bark would be made available when the timber is harvested. From this bark, a tannin extract can be produced which can be used as wood adhesives for the manufacture of wood based composites. Bark of other *Acacia* species particularly *A. mearnsii* have been widely investigated (Pizzi and Scharfetter 1978) and their tannins have been commercially extracted to produce tannin based wood adhesives (Pizzi and Scharfetter 1978). In view of the current shortage of supply and the indefinite price increase of phenol worldwide, it is desirable to find cheaper source of phenolic, preferably from renewable resources.

Tannins are naturally occurring polyphenolic compounds and are soluble in water. They have been traditionally used in the leather industry due to their ability to interact with protein in animal skin. Normally, tannins consist of high molecular weight phenolic compounds ranging from 500 to 30 000 mw (Hemmingway et al. 1989; Hoong et al. 2009).

Tannins can be divided into two categories; hydrolysable tannins and condensed tannins. Hydrolyzed tannins have low reactivity towards formaldehyde due to lack of macromolecular structures and also low nucleophilicity, limiting its usage in worldwide adhesive production, which in turn decrease their chemical interest and economical value. Condensed tannins contain complex chemical structures of polyphenolic compounds, which have higher reactivity towards formaldehyde than phenol. Due to their phenolic nature, condensed polyflavonoid tannins from various plant sources such as tree barks or nutshells were studied as possible replacement for phenolic materials in adhesive resins. In-depth studies by various researchers on polyflavonoid tannins have led to the understanding of structures, reactions, and potential usage of these condensed tannins from different sources (Pizzi 1983).

Extensive research in the use of tannins as a substitute for phenol in wood adhesive formulation has been done in Australia, South Africa, Korea, Europe, and North America. The usage of tannins is 6000 ton/year in Australia, 1500 ton/year in Japan, 500 ton/year in Zimbabwe, 400 ton/year in Chile, and 100 ton/year in Europe. Thus, these natural based polyphenolic resources have a huge potential market for wood-based industries worldwide (Hoong et al. 2009). Therefore, tannin is an excellent renewable resource which can be used for replacing petroleum-derived phenolic compounds.

1.2 Problem statement

Synthetic resins such as Urea Formaldehyde (UF), Phenol Formaldehyde (PF) and Melamine Urea Formaldehyde (MUF) have been used widely in wood panels manufacturing but they are expensive and produce formaldehyde emission which is not good for our health. There has been growing concern over formaldehyde emissions in urea formaldehyde (UF) and PF bonded particle board and ply-boards. It is now known that adhesives produced from tannin, if properly cured, give nearly zero formaldehyde emission. Much of the work on tannin-based adhesives has been focused on developing resins for exterior applications as well as lowering formaldehyde emission levels.

In our country, *Acacia mangium* is one of the fast growing dicotyledon species not only in Malaysia but also in the rest of Asia. *A. mangium* trees have been planted under the forest plantation program both in Malaysia and Indonesia. Normally, this fast growing tree is utilized as raw material for pulp and paper production due to its small log diameter characteristics as well as for glulam production because of its high bonding strength (Hoong et al. 2009). The resources of tannin from *A. mangium* bark is said to be plenty and always wasted. Therefore, tannin extracted from *A. mangium* bark can be an alternative to replace these synthetic resins.

1.3 Objectives

The objectives of this study are:

- i. To study the reaction of *A.mangium* tannin with furfuryl alcohol by gel time.
- ii. To determine the physical and mechanical properties of particle board made from tannin-furfuryl alcohol.



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