EFFECT OF SOLVENT TYPES ON THE PHYSICAL PROPERTIES OF TANNIN-PHENOL FORMALDEHYDE ADHESIVE

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By

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DEDICATION

Special dedication to my beloved parents

(Allen Mah & Thor Chun Ken)

My beloved brother,

(Evin Mah)

My friends,

(Chen Yuen Ling, Wong Zhi San and Lim E Yee)

Thank you for all your help and support whenever I needed.

ABSTRACT

The main objective of this study was to determine the effect of solvents and types of *Acacia mearnsii* tannin on the physical properties of tannin phenol formaldehyde (TPF) resin. In this study, two types of tannins (Australia and Italy) at three ratios (20%, 30% and 40%) of tannin solution with five types of solvents (distilled water, ethanol, sodium sulphate, methanol and glycerol) were used. The tannin solution was mixed with commercial phenol formaldehyde (PF) resin to produce TPF resin. Meanwhile commercial PF resin was used as control. The results showed that, TPF resin using both types of tannin have similar trend of pH, viscosity, solid content and gel time when any types of solvent were used. Generally, as the tannin ratio increased, the pH and solid content decreased, gel time shorter and viscosity increased in any types of solvents. Findings show that the tannin of Italy has better water resistance compared to Australia tannin. Apart of distilled water, TPF consists of other solvents had higher viscosity compared to distilled water. Glycerol offers fast gel time, highest viscosity and solid contents properties of TPF resin.

ABSTRAK

Objektif utama kajian ini adalah untuk menentukan kesan pelarut dan jenis *Acacia mearnsii* tanin pada sifat-sifat fizikal resin tanin fenol formaldehid (TPF). Dalam kajian ini, dua jenis tanin (Australia dan Itali) di tiga nisbah (20%, 30% dan 40%) daripada rumusan tanin dengan lima jenis pelarut (air suling, etanol, natrium sulfat, metanol dan gliserol) telah digunakan. Rumusan tanin telah bercampur dengan resin fenol formaldehid komersial (PF) untuk menghasilkan TPF resin. Sementara itu resin PF komersial telah digunakan sebagai kawalan. Keputusan menunjukkan bahawa TPF resin menggunakan kedua-dua jenis tanin mempunyai trend pH, kelikatan, kandungan pepejal dan masa gel yang sama apabila mana-mana jenis pelarut yang digunakan.Secara umumnya, sebagai nisbah tanin meningkat, pH dan kandungan pepejal menurun, masa gel lebih pendek dan kelikatan meningkat dalam mana-mana jenis pelarut.Hasil kajian menunjukkan bahawa tanin Itali mempunyai rintangan air yang lebih baik berbanding dengan tanin Australia.Selain daripada air suling, TPF terdiri daripada pelarut lain mempunyai kelikatan yang lebih tinggi berbanding dengan air suling. Gliserol menawarkan masa gel cepat, kelikatan dan kandungan pepejal sifat tertinggi resin TPF.

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APPROVAL SHEET

I certify that this research project report entitled "**EFFECT OF SOLVENT TYPES ON THE PHYSICAL PROPERTIES OF TANNIN-PHENOL FORMALDEHYDE ADHESIVE**" by **Heather Mah Lixia** 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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LIST OF ABBREVIATION

PF	Phenol Formaldehyde
TPF	Tannin Phenol Formaldehyde
MTIB	Malaysian Timber Industry Board
ANOVA	Analysis of Variance
LSD	Least Significant Difference Test
%	Percent
°C	Degree Celsius
° F	Degree Fahrenheit
cP	Centipoise
g	Gram
ml	Milliliter

CHAPTER 1

INTRODUCTION

1.1 Background

Tannins are a class of natural polyphenols found in terrestrial plants, which have been subject of extensive research leading to the development of a wide range of industrial applications (Pizzi, 1994). They are most commonly obtained from wood and bark and are used as substitutes for synthetic resins due to their characteristic to precipitate with formaldehyde forming a polymer of rigid structure (Gonçalves and Lelis, 2000). Tannins comprise two different classes of polyphenolic compounds; hydrolysable tannins and condensed tannins. The hydrolysable tannins are mixture of simple phenols while the condensed tannins are polymeric phenolic compounds comprising from flavon-3-ol repeating units (Feng et al*.,* 2013). According to Feng et al. (2013), condensed tannins are known for their wide distribution in various softwood and hardwood, and it constitutes about 90% of the total world production of commercial tannins.

Today, in addition to oak (*Quercus* sp.), there are many other plant species that are being used to produce commercial tannins. These include plants like *Acacia* sp. (wattle), *Eucalyptus* sp., *Mirtus* sp. (myrtle), *Acer* sp. (maple), *Betula* sp. (birch), *Salix Caprea* (willow) and *Pinus* sp. (pine) (Bisanda et al., 2003). Pizzi et al. (1982) claims that the main sources that have been commercialize for condensed tannins are quebracho (*Schinopsis balansae*) wood and the barks of black wattle (*Acacia mearnsii*) and chestnut (*Castanea Sativa*). In addition, the types of tannins found are determined by the species and extraction methods (Kilic et al*.*, 2011; Vazquez et al., 2001).

Tannin extracted from *Acacia mearnsii* is one of the commercialized tannin for adhesive application. According to Maslin and McDonald (2004), the tannin produced by the bark of *A. mearnsii* has good waterproof adhesive properties for the production of reconstituted-wood and is used in adhesives for exterior grade plywood, particleboard, laminated timber and numerous other industrial applications.

In previous study done by Pizzi (1979), sulfitation in tannin adhesive application offers low viscosity, enhanced solubility, higher moisture retention by the tannin resin and allowing slower adhesive film dry-out. Solubility alteration of chemicals is needed in many industrial uses, and the solvent mixing is one of the most frequent and feasible methods employed in the industry. A wide range of solubility for a given compound can be achieved by using different ratios of the solvents. Hence, the selection of solvents for tannins mixing may affect the physical properties of tannin-phenol formaldehyde and the choice of the solvent may control the formation of reaction products.

1.2 Problem Statement and Justification

Tannins derived from the vast majority of tree species such as pine, acacia and oak has been of a technical nature such as the low solubility, high molecular weight, high viscosity and fast reactivity with formaldehyde which lead to very short glue mix pot-lives (Pizzi, 1980). As *Acacia mearnsii* was reported to have a good waterproof adhesive properties (Maslin and McDonald, 2004), *A. mearnsii* tannin was used as selected tannin for current study.

Tannin was also reported to have differences in their physico-chemical properties such as water solubility and chemical reactivity (Tanaka et al., 1999). According to Ohunyon and Ebewele (1992), most of the tannin adhesives previously reported had serious disadvantages such as weaker strength of bonded composites, brittleness, poor wood penetration, and poor wet strength due to the solubility properties. Reasons for these shortcomings include the tannin molecules are big and therefore cannot rotate freely about their backbone which results in the observed inherent brittleness.

The current tannin from *Acacia mearnsii* uses water as extraction medium. The present investigation revealed otherwise since water which is a very cheap solvent, has been established to be very efficient in tannin extraction. In the same vein, Dametey (2010) found water to be very efficient in removing tannins from *Acacia mangium* and *Acacia auriculiformis* barks as well as *Pinus oocarpa* leaves.

Even though the tannin produced from this method is relatively pure (more reactive site) but the yield is very low (less than 15%). The tannin yields were quite lower using distilled water as solvent than expected, considering the work of earlier researchers. This could be attributed to the difference in the extraction methods. Several studies were carried out for tannin extraction using other solvents and techniques. For instance, *Pinus oocarpa* bark was extracted using sulfite of sodium as solvent by Ferreira et al. (2008). Similar studies were carried out on solvent and supercritical extraction to obtain natural tannins from *Acacia* spp. barks by Pansera et al. (2004). Therefore, it is important to investigate the solubility of *A. mearnsii* tannin with other solvent so that it can be used as extraction medium.

1.3 Objectives

1. To determine the physical properties of tannin-phenol formaldehyde resin when different types of solvent is added.
2. To evaluate the effect of tannin ratio on the properties of tannin phenol formaldehyde.

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