UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF MEDIUM DENSITY FIBREBOARD MANUFACTURED FROM EXTRACTED AND UNEXTRACTED ACACIA CATECHU WOOD CHIPS

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BY

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ABSTARCT

The project was carried out to evaluate the properties of medium density fibreboard from the extracted and unextracted woodchips. The boards were produced with a 13 % urea resin, and a 3 % isocyanate resin to obtain three densities which were targetted at 650, 750, and 850 kg/m^3. The same resin concentrations and types were used to produce board of the target density of 750 kg/m^3. The properties of the boards from the extracted and unextracted materials were determined and compared.

The chemical components of the wood were 64.27 % holocellulose, 35.63 % alhpa-cellulose, 34.38 % lignin and 1.5 % ash, with the pH of 5 to 5.1.

The extracted woodchips yielded 88.35 % fibre whilst the unextracted woodchip yielded 77.92 % fibre.

The strength properties of boards from the extracted woodchip with 13 % urea resin met the 300-type of JIS A 5906 for all three densities. The boards with 3 % isocyanate resin met the 150-type for 650 kg/m^3 and 750 kg/m^3 and met the 300-type for 850 kg/m^3. The urea bonded boards gave higher strength than those bonded by isocyanate resin.

The 750 kg/m^3 boards from the unextracted woodchip gave higher MOR with the urea than the isocyanate resin.

The boards with urea resin met 300-type, whilst the boards with isocyanate resin only met the 150-type.

The boards from the extracted woodchips showed significantly higher strength values than the unextracted woodchip boards but the internal bonding and thickness swelling were not significantly different between different resins, densities, and material types.

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CHAPTER I

INTRODUCTION

Acacia catechu Willd (trade name: cutch or catechu tree) is found naturally in a mixed deciduous forest in Thailand and also widely distributed in India. In Thailand, the species has been grown in plantation since 1959 for fuel and medicinal purposes. The planted area is about 3,500 hectares. The species contains a certain amount of katha and cutch. The heartwood is the raw material to produce katha and cutch by means of hot-water extraction. The extraction yield are extracted woodchip and filtrate. After the filtration is cooled down, katha crystallises out from the concentrated filtrate. Filtering the katha out, the liquid remaining is further evaporated.

Katha is used for chewing. Cutch is used as a tanning agent for leather, a cheap dye for canvas, fishing nets, and in oil well drilling as a viscosity modifier of drilling mud (Royal Forest Department, 1988). Cutch is also used as astringent for diarrheea and sore throat. The extracted woodchip is used only as fuel.

The A. catechu Willd is generally found as a medium size tree, crooked, thorny, and with a light feathery crown. The sapwood is creamy white in colour, the heartwood is brown and turns black on exposure. The wood

is spiral grain with high specific gravity (1.07 based on wet volume).

Medium density fibreboard (MDF) is a special product of recent development. It is a dry process product which uses resins as bonding agents. Density ranges from about 500 to 800 kg/m^3. The process is mainly the practical elimination of water and the production of two side smooth board in a range of thicknesses. It is a high quality product generally intended for the furniture industry. The product is evenly textured that it opens up many new ap[plications in the manufactured and building products. The dense-packed, even textured of the core makes MDF a perfect material for surface moulding. The uniform, smooth and tight edges can be machined like solid wood.

The wood is defibrated into fibres which are reconstituted into into MDF. Small diameter logs and lesser known species can be an important source of raw material. The MDF, as a versatile product will have to meet increasingly complex and demanding end uses.

Objectives

1. To study the possibility of using A. catechu Willd for the production of medium density fibreboards.

2. Determine the properties of MDF from extracted and unextracted woodchips.

3. Comparing the properties of MDF at different densities (650, 750, and 850 kg/m^3).

4. Comparing the properties of MDF with urea resin and isocyanate resin.

CHAPTER III

LITERATURE REVIEW

The product was introduced in the mid-1960s. The wide variety of raw materials can be used for the production of medium density fibreboards (MDF). The wood is chipped, steamed and passed through refiner making the wood into fibres (Maloney 1977). Resin binders or adhesives are added to bond individual fibres together. Adhesives improved the physical properties, other chemicals are also added to improve special purpose such as insects and fungi, and moisture resistance. MDF is manufactured to the density of 400 kg/m^3 to 800 kg/m^3 according to the Japanese Industrial Standard (A 5906-1983). Most of the boards produced in the MDF process is over 3/8 inch in thickness and goes to the furniture industry. The dry process is developed to take advantage of less release of effluent from industrial operations.

Materials

The hardwoods chemical components ranged from 1 to 5 % in total extractives, 20 - 31 % for lignin and 40 - 51 % for cellulose. Acacia mollisima (black wattle) contained 1.8 % extractives, 20.8 % lignin and 42.9 % cellulose (Sjostrom 1981). Acacia catechu is a hardwood of high specific gravity with a value of 0.874 g/cm^3 for 29 year

old trees (Sakpichit 1989). The water soluble extractives were 8.5 % katha, and 3.6 % cutch based on dried weight (Royal Forest Department 1989). The fibres of A. catechu are short, measuring not more 3 mm in length. In India this species is a valuable tree for the manufacturing katha and cutch by hot water extraction. The species is distributed in the greater part of India except the most humid and drier region. There is no report on use this species other than for fuel and extraction for katha and cutch.

Urea resin

About 90 % of the world composition board production is made with urea resin. It is low in cost, white or colourless, easy to use and have fast reaction. Urea resin boards are not suitable for exterior application. The phenol-formaldehyde resins are more favourable for the exterior type products.

Urea-formaldehyde (UF) resins consists of relatively high molecular weight polymers of urea and formaldehyde and dispersed in a water medium. The reactive end group of UF are methylol groups. The addition of urea into resin is to reduce the level of unreacted formaldehyde in the liquid resin and to increase the amount of active end groups present in the resin. During the curing process in

the hot press, a primary source of formaldehyde release from UF binders is believed to be the degradation of active end groups which are not completely reacted. The low melecular weight methylol-urea (Figure 1) is believed to be involved in reducing the formaldehyde odor of the liquid resin.

NH_2-CO-NH-CH_2OH

monomethylol-urea

$HOCH_2$-NH-CO-NH-CH_2OH

or

NH_2-CO-N-$(CH_2OH)_2$

dimethylol-urea

$HOCH_2$-NH-CO-N-$(CH_2OH)_2$

trimethylol-urea

Figure 1 methylol-urea (Kelly 1970)

Urea formaldehyde resins are cured under acidic condition, this can be attained by catalyst such as ammonium sulfate or ammonium chloride. The resin has a relatively short pot life once added catalyst. The parameters for the reaction are temperature, time of reaction, the pH value and chemical concentration. The reaction can take place in the pH of 5.0 to 5.5. It a reported that the medium density fibreboard with 13% urea

resin based on oven-dry weight of fibres manufactured for 400, 500, 600 kg/m^3 board densities having the strength properties generally met the JIS 5906. The modulus of rupture were 86-97, 147-174, and 227-313 kg/cm^2 for 50 type, 150-type, and 200-type respectively (Tomimura, Y., et al 1987).

Isocyanate resin

Isocyanate resin has been reported to be used as binding agent for particleboards in commercial practice since 1975. (Frich, K. C., Rumao, L. P., and Pizzi, A.) It is an expensive, but extremely an effective binder. The advantages are that no water is contained in the system, excellent adhesion to wood and to many other materials. Resistance to moisture and elevated temperature varies widely, and excellent chemical ageing resistance. It is suitable for exterior products. The disadvantages are being high in cost, adheres firmly to aluminum and some steel, causing problem with bonding to caul plates and press parts. It is important to add catalyst to the resin to bring about faster reactions rates and to establish a proper balance between the wood-to-adhesive cross-linking reaction (the hydroxyl-isocyanate reaction) and isocyanate-wood water content reaction. Another important function is to complete the reaction which

results in maximum strength properties. It was reported that the diisocyanate used for the manufacture of particleboard is commercial polymeric MDI(MDI=4,4'-diphenylmethane diisocyanate). MDI is the mixture of the isomers of dimer, trimer, and higher polymeric isocyanates. The advantages of MDI binder to particleboard and plywood is that better bonding is obtained over the traditional adhesive systems and less pressing time.

CHAPTER III

MATERIALS AND METHODS

Materials

Twenty year olds A. Catechu Willd were obtained from Pang - asoke plantation, Nakornrachasima province, Thailand. The log diameters averaged between 20 to 25 cm.

The resin adhesives were urea formaldehyde (Casco Resin WW-17A) and isocyanate resin. The solvent was acetone for isocyanate resin. Teflon coated release paper was used to prevent the mattress from the sticking of resin to the platens or caul plates.

Raw material preparation

The selected logs were cut into planks and chipped. The woodchips were dried at room temperature (about 26-32^{o}C) and then extracted by hot water for 2 hours. The woodchips were then air dried at room temperature after which were sreened to four sizes. Those are bigger than 2.54 cm (>1 inch), >1.91-2.54 cm (>0.75-1 inch), >0.64-1.91 cm (>0.25-0.75 inch), and < 0.64 cm (<0.25 inch).

The moisture content of woodchips

About 5 g woodchips were weighed (2 decimals) and dried at 105 ± 3^{o} C for least 24 hours and then placed in a desiccator for 15 minutes before weighing.

Calculation:

$$MC.(\%) = \frac{\text{air dried weight - ovendried weight}}{\text{air dried weight}} \times 100$$

Chemical component analysis

The unextracted woodchips were ground and screened through the 40-60 mesh. Then the chemical components were determined in accordance with the following standards:

Determination of moisture content (TAPPI standard T 207 os 75).

Determination of cold water solubility of wood (TAPPI standard T 207 os 75).

Determination of hot water solubility of wood (TAPPI standard T 207 os 75).

Determination of alcohol-benzene solubility of wood (TAPPI standard 207).

Determination of 1 % NaOH solubility of wood (TAPPI standard T 212 os 76).

Determination of lignin in wood (TAPPI standard T 222 os 74).

Determination of holocellulose of wood (the method of Wise, Murphy and D'Addieco).

Determination of alpha-cellulose of wood (TAPPI standard T 203 os 61).

Determination of ash in wood (TAPPI standard T 15 os 58).

Preparation of wood fibres

The woodchips were put into a vessel, steamed at 135^{o}C for about 5 minutes, then passed through refining plate (single plate 12 inches) with 0.01 clearance, at a setting pressure at 60 kg/in^{2} for 8-12 minutes. The fibre produced, were then put in the oven until the moisture content was about 5 %. The fibres were weighed to obtain the percentage yielded: calculated the fiber yield as follow:

$$\text{fibre yield (\%)} = \frac{\text{oven dried weight fibre}}{\text{oven dried woodchip}} \times 100$$

Fraction fibre analysis

About 10 g of fibres were weighed (oven dried weight), disintegrated for 3,000 cycles in 2 litres of

water, then passed through the screens (40, 70, and 140 mesh) for 20 minutes in accordance with TAPPI Standard T 233 os 75. The fibre fractions were collected, dried at 105±3°C until constant weight. They were weighed after cooled in a desiccator. The percentage of fibre fraction were calculated.

$$\text{fibre fraction (\%)} = \frac{\text{fibre fraction X 100}}{\text{oven dried weight}}$$

The fibre lengths were determined by profile projector V-12 (with 50x magnification).

PH of wood and fibre

One gram of oven dried fibre was weighed, soaked in 70 ml of distilled water. The mixture was left for 1 hour to record pH and temperature of the mixture. The pH and temperature of sawdust slurrly was recorded by the same procedure.

Manufacture of medium density fibreboard

The fibres were weighed, then put in a blender. The moisture content of dried fibre was 5 to 7 %. The amount of used resin were 13 % for urea resin and 3 % for isocyanate resin. Fibres and resins were mixed together by using spray gun is a rotating blender. The mixed glue fibre was passed through a refiner before mat forming. A

stainless steel caul plate was placed over by a teflon release paper. The glue mixed fibre was hand spreaded over a teflon paper. The mat was then cold pressed at about 20 kg/cm^2 for 1 minute . The top of the mat was placed with teflon release paper and the second caul plate was placed on the top of it. The mat was loaded in a hot press with the setting temperature of 160^oC. The pressure was applied into 2 steps.

Initial full pressure at 46 kg/cm^2 (1200 psi) for 1 minute followed by 30 kg/cm^2 800 psi for 4 minutes.

There were 3 replications for each type of board giving a total of 24 boards (see Table 1).

Table 1 Number of produced MDF

material	density (kg/m^3)	urea	isocyanate
extracted woodchip	650	3	3
extracted woodchip	750	3	3
extracted woodchip	850	3	3
unextracted woodchip	750	3	3
total		12	12

The boards were conditioned in a room at temperature 20^{o}C $\pm$ 2^{o}C and 65 % $\pm$ 5 % relative humidity at least 7 days before cutting into specimens.

Testing of specimens

The boards were trimmed into 30 mm x 30 mm after conditioning. Two specimens for each board were tested for internal bonding, thickness swelling, bending strength (for modulus of rupture, MOR, modulus of elasticity, MOE) at dry test condition, and bending strength (MOR, MOE) at wet test condition. One specimen each was used for the determination of density and measurement of thickness respectively each board. thickness measurement for each board. Dry test condition was at 20 ^{o}C $\pm$ 2^{o}C and 65 % $\pm$ 5 % relative humidity and wet test condition was boiled in water 100^{o}C for 2 hours, followed by 1 hour soaked in cold water (room temperature) before testing.

The specimen dimension and testing were carried out according to the Japanese Industrial Standard Medium Density Fibreboards JIS A 5906. The cutting pattern of test specimens is as shown in Figure 2.

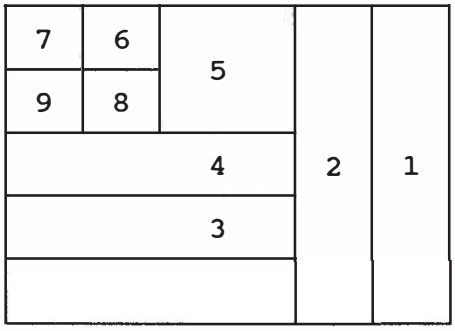

Figure 2 cutting pattern of the MDF specimen

1, 4 = specimens for MOR and MOE (wet test condition)

2, 3 = specimens for MOR and MOE (dry test condition)

5 = specimen for thickness and density

6, 9 = specimens for internal bonding

7, 8 = specimens for thickness swelling

Data analysis

A completely randomized design was used in the study. The analysis of variance was carried out to determine the effect of different types of resin (urea and isocyanate resin). The analysis variance of mean (strength properties) at different board densities, and the effect between materials (extracted woodchips and unextracted woodchips).