UNIVERSITI PUTRA MALAYSIA

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

CHEMICAL MODIFICATION OF SESENDUK [*Endospermum diadenum* (Miq.) Airy Shaw] WOOD WITH LOW MOLECULAR WEIGHT PHENOL FORMALDEHYDE

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Faculty : Forestry

Low-density wood, sesenduk (*Endospermum diadenum*) has great a potential to substitute commercial timber, if its properties can be improved. One of the potential processes to enhance the properties of this timber is through bulking treatment with phenolic resin and rendered them insoluble in the wood.

The objective of this study was to enhance the properties of sesenduk wood through bulking treatment with low molecular weight phenol formaldehyde (LmwPF, M_w = 600). The effect of initial moisture content (MC), duration of soaking in the treating solution and incorporating urea in the PF resin on the properties and formaldehyde emission of the treated wood were investigated. Wood strips of dimension 10mm x 50mm x 150mm (*impreg*) and 20mm x 50mm x 150 mm (*compreg*) with initial MC of 15, 25 and >40% were

impregnated with 15% LmwPF using a vacuum-pressure process. The samples were left soaked under pressure for 30, 60 and 120 min. The effect of the processing variables on the treatability of the wood was then analyzed. After impregnation, the treated samples were partially cured at 65 °C for 6 h and subsequently compressed to a compression ratio of 50% in a hot press maintained at 150±2 °C for 60 min. In the second part of the study, urea (formaldehyde catcher) at concentrations of 10, 20, and 30% (based on solid PF) were incorporated separately in the PF resin and these mixture were used as treating solution to treat the wood. The treatment without urea and untreated solid wood served as controls for comparison purposes.

The results showed that the initial MC of the wood significantly ($p<0.05$) affected polymer retention (PR), while soaking time affected PR and weight percent gain (WPG) of the treated material. The highest PR and WPG were attained by samples with initial MC of 25%. For each initial MC group, soaking for 120 min yielded the highest PR and WPG. The results also showed that there is positive correlation between PR and WPG.

For *compreg* sesenduk, initial MC significantly affects WPG while soaking time did not have any significant effect on WPG. The highest and the lowest WPG were at 15% and 40% of initial MC respectively.

Statistical analyses board properties showed that WPG had positive correlation with density, and reduction in water absorption (R_{abs}), but negative correlation with thickness swelling when tested soaking distilled

water and exposure to humidity. Nevertheless, there is no significant ($p>0.05$) correlation between WPG and volumetric swelling coefficient (S) or anti-swelling efficiency (ASE) of the *compreg*.

Formaldehyde emission (FE) was significantly reduced when urea was incorporated in the treating solution and the degree of reduction increased with urea concentration. *Compreg* products produced with/without the addition of urea had mechanical properties superior compared to untreated wood; however, the swelling coefficient was inferior which was probably due to the residual effect of the compression. When compared among the treatment combinations, *compregs* produced without urea had mechanical properties higher than those treated with the mixture.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KIMIA PENGUBAHSUAIAN KAYU SESENDUK [*Endospermum diadenum* (Miq.) Airy Shaw] DENGAN FENOL FORMALDEHID BERAT MOLEKUL RENDAH

Oleh

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Kayu berketumpatan rendah, sesenduk (*Endospermum diadenum*) mempunyai potensi yang besar untuk menggantikan kayu komersial, jika sifat-sifat kayu ini boleh diperbaiki. Salah satu proses yang berpotensi untuk meningkatkan sifat-sifat kayu ini adalah melalui rawatan pukal dengan resin fenolik dan menjadikan ia tidak larut di dalam sel kayu.

Objektif kajian ini adalah untuk meningkatkan sifat-sifat kayu sesenduk melalui rawatan pukal dengan fenol formaldehid berat molekul yang rendah (LmwPF, Mw = 600). Kesan kandungan lembapan permulaan (MC), tempoh rendaman dalam larutan pengawet dan kesan penambahan urea dalam resin PF ke atas sifat dan pelepasan formaldehid pada kayu yang dirawat telah disiasat. Kayu jalur berukuran 10mm x 50mm x 150mm (*impreg*) dan 20mm x 50mm x 150 mm (*compreg*) dengan MC permulaan sebanyak 15, 25 dan

>40% telah diimpregnasi dengan menggunakan LmwPF 15% melalui proses vakum tekanan. Sampel-sampel dibiarkan terendam di bawah tekanan selama 30, 60 dan 120 minit. Kesan pembolehubah pemprosesan pada kebolehrawatan kayu telah dianalisis. Selepas diimpregnasi, sampel terawat dimatangkan secara separa pada suhu 65ºC selama 6 jam dan kemudiannya dimampatkan dengan nisbah mampatan sebanyak 50% dalam penekan panas pada suhu 150±2 ºC selama 60 minit. Dalam bahagian kedua kajian ini, urea (penangkap formaldehid) pada kepekatan 10, 20, dan 30% (berdasarkan pepejal PF) telah dicampurkan ke dalam resin PF secara berasingan dan campuran ini telah digunakan sebagai larutan pengawet untuk merawat kayu. Rawatan tanpa urea dan kayu pepejal tidak dirawat digunakan sebagai kawalan untuk tujuan perbandingan.

Keputusan menunjukkan bahawa MC awal kayu ketara ($p<0.05$) memberikan kesan signifikan pada penahanan polimer (PR), manakala masa rendaman memberikan kesan yang signifikan pada PR dan peratus penambahan berat (WPG) bahan yang dirawat. PR dan WPG tertinggi telah dicapai oleh sampel dengan MC permulaan 25%. Bagi setiap kumpulan MC, rendaman selama 120 minit menghasilkan PR dan WPG tertinggi. Keputusan juga menunjukkan bahawa terdapat korelasi yang positif antara PR dan WPG.

Untuk *compreg* sesenduk, MC awal memberi kesan signifikan pada WPG manakala masa rendaman tidak mempunyai apa-apa kesan yang signifikan pada WPG. WPG tertinggi dan terendah masing-masing diperoleh pada 15% dan 40% MC awal.

Analisis statistik terhadap sifat papan menunjukkan bahawa WPG mempunyai korelasi positif dengan ketumpatan, dan pengurangan dalam penyerapan air (R_{abs}), tetapi berkorelasi negatif dengan pembengkakan kayu apabila direndam dengan air suling dan didedahkan kepada kelembapan. Walau bagaimanapun, tidak terdapat korelasi yang signifikan ($p>0.05$) antara WPG dan pekali pembengkakan isipadu (S) atau kecekapan anti-pembengkakan (ASE) *compreg*.

Pelepasan formaldehid (FE) telah dikurangkan dengan ketara apabila urea telah dicampurkan ke dalam larutan pengawet dan tahap pengurangan meningkat dengan kepekatan urea. Produk *compreg* yang dihasilkan dengan atau tanpa tambahan urea mempunyai sifat-sifat mekanik terbaik berbanding kayu yang tidak dirawat; bagaimanapun, S adalah lebih rendah yang mungkin disebabkan oleh kesan sisa mampatan. Apabila dibandingkan antara gabungan rawatan, *compreg* yang dihasilkan tanpa urea mempunyai sifat mekanikal yang lebih tinggi daripada mereka yang dirawat dengan campuran.

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I certify that an Examination Committee has met on 28 May 2012 to conduct the final examination of Tri Padukan Purba on his thesis entitled "Chemical Modification of Sesenduk [*Endospermum diadenum* (Miq.) Airy Shaw] Wood with Low Molecular Weight Phenol Formaldehyde" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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TRI PADUKAN PURBA

Date: 28 May 2012

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