UNIVERSITI PUTRA MALAYSIA

EFFECTS OF FORMALDEHYDE CATCHERS ON EMISSION OF FORMALDEHYDE AND DIMENSIONAL STABILITY OF RUBBERWOOD PARTICLEBOARD

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By

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Abstract of thesis presented to the Senate of the Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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Chairman: Associate Professor H'ng Paik San, Ph.D.

Faculty: Forestry

Formaldehyde catcher, although, effective in reducing formaldehyde emission, affect the dimensional stability of particleboard produced. Dimensional instability is undesirable because the swelling process when exposed to water, functionally and visually, bring about gradual structural deterioration resulted in lower strength and degraded surface appearance. Thus, this study aimed to establish optimum processing parameters to work with this post-treatment and add-in formaldehyde catcher in order to produce particleboard with formaldehyde emission and properties particularly dimensional stability that comply with Japanese Industrial Standard. The processing parameters include different amount of particles used for surface layer and core layer (surface-to-core ratio), resin content, types of application method and the types of catcher used. Rubberwood was used as the main raw material in this study. Type E1 urea formaldehyde resin was used as the binder. Wax and hardener was also added to the resin. The code name for formaldehyde catcher applied on the surface of the boards after conditioning (post-treatment) was SF1188. On the other hand, formaldehyde catchers added into the adhesive mixture (add-in) were named as Catcher 1, Catcher 2 and Catcher 3 with the active ingredient amino compound, glycerol and melamine respectively. The tests for physical and mechanical properties were conducted in accordance with JIS A 5908:2003. Statistical analysis (ANCOVA or ANOVA) was carried out to determine the effects of the variables on the board's properties. Pearson's correlation was also been carried out to measure the strength of association between the studied variables and properties of particleboard. The results show that, particleboard produced using of 60% surface particles and 40% core particles had the highest Modulus of Rupture (MOR) and second lowest thickness swelling (TS) for the particleboard manufactured. Boards applied with the highest dosage of post-treatment formaldehyde catcher show a reduction of approximately 70% of formaldehyde emission. The lowest formaldehyde emission value for add-in formaldehyde catcher came from the boards applied with Catcher 1 (0.211 mg/L). Overall, particleboards applied with 60 gm^{-2} of post-treatment catcher and 6% of add-in catcher show the lowest formaldehyde emission, with the lowest value achieving 0.163 mg/L. Despite the low formaldehyde emission, these boards were in poor dimensional stability.

Therefore, optimization was carried out by the application of heat treatment and the selection of specific mat moisture (3-11%) to impart better dimensional stability and lower formaldehyde emission upon the particleboard. Particleboards produced with 9% mat moisture show the lowest thickness TS value (11.67%). Heat treatment at 170 ℃ further reduced the TS value to 10.87%. Also, formaldehyde emission for samples treated at 170 ℃ successfully achieved Super E0 level. In conclusion, particleboards which complied with all criterions stated in JIS A 5908:2003 was successfully produced by the combination of formaldehyde catcher and dimensional improvement with careful selection of mat moisture and heat treatment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PENANGKAP FORMALDEHID KE ATAS PELEPASAN FORMALDEHID DAN KESTABILAN DIMENSI PAPAN SERPAI KAYU GETAH

Oleh

LUM WEI CHEN

June 2014

Pengerusi: Profesor Madya H'ng Paik San, Ph.D.

Fakulti: Perhutanan

Penangkap formaldehid, walaupun berkesan untuk mengurangkan pelepasan formaldehid, menjejaskan kestabilan dimensi papan serpai yang dihasilkan. Dimensi yang tidak stabil adalah tidak diingini kerana proses pengembangan akan berlaku apabila didedahkan kepada air. Kekuatan papan serpai yang rendah akan menyebabkan kemerosotan pada fungsi dan visual papan. Oleh itu, kajian ini bertujuan untuk mencari parameter pemprosesan yang optimum untuk digunakan dengan penangkap formaldehid pos-rawatan dan pre-rawatan untuk menghasilkan papan serpihan dengan pelepasan formaldehid dan sifat-sifat yang mematuhi Standard Perindustrian Jepun. Parameter pemprosesan yang digunakan merangkumi nisbah partikel permukaan kepada partikel teras, kandungan resin, jenis penangkap formaldehid, dan juga kaedah aplikasi. Partikel kayu getah digunakan sebagai bahan mentah utama dalam kajian ini. Resin urea formaldehid jenis E1 digunakan sebagai pengikat. Lilin dan pembangkit juga ditambah kepada resin. Nama kod bagi penangkap formaldehid yang disapu ke atas permukaan papan selepas dikondisi (pra-rawatan) adalah SF1188. Penangkap formaldehid yang ditambah dalam campuran resin (tambah-masuk) dinamakan sebagai Penangkap 1, Penangkap 2 dan Penangkap 3 dan mempunyai bahan aktif kompaun amino, glycerol dan melamin masing-masing. Ujian untuk sifat-sifat fizikal dan mekanikal telah dijalankan selaras dengan JIS A 5908:2003. Analisis statistik (ANCOVA atau ANOVA) telah dijalankan untuk menentukan kesan bagi pembolehubah yang dikaji. Pearson's correlation juga telah dilakukan untuk mengukur kekuatan yang wujud antara pembolehubah yang dikaji dengan sifat-sifat papan serpihan. Keputusan menunjukkan bahawa papan serpai yang dibuat dengan mennggunakan 60% partikel permukaan dan 40% partikel teras mempunyai nilai MOR yang paling tinggi dan nilai TS yang kedua terendah. Nilai terendah pelepasan formaldehid bagi papan pra-rawatan menunjukkan pengurangan sehingga 70%. Nilai yang paling rendah bagi pelepasan formaldehid merupakan papan yang dirawat dengan Penangkap 1 (0.211 mg/L). Secara keseluruhannya, papan serpai

yang dirawat dengan 60 gm^{-2} penangkap formaldehid pra-rawatan and 6% penangkap formaldehid tambah-masuk memberikan nilai pelepasan formaldehid yang paling rendah, dengan nilai yang paling rendah mencapai 0.163 mg/L. Walaupun tahap pelepasan formaldehid amat memuaskan, sifat-sifat mekanik papan serpai yang dirawat dengan formaldehid masih menunjukkan kestabilan dimensi yang lemah dan gagal untuk mencapai keperluan JIS. Oleh itu, pengoptimuman telah dilakukan dengan menggunakan rawatan pasca haba dan pemilihan tahap kelembapan yang spesifik (3-11%) untuk mencapai kestabilan dimensi yang lebih baik serta tahap pelepasan formaldehid lebih rendah. Papan serpai yang dihasilkan dengan 9% kelembapan mat memberikan nilai TS yang paling rendah (11.67%). Rawatan haba pada 170 ℃ berjaya menurunkan lagi nilai TS kepada 10.87%. Selain itu, pelepasan formaldehid bagi papan sampel yang dirawat dengan 170 ℃ juga berjaya mencapai level Super E0. Kesimpulannya, papan serpihan yang mematuhi semua kriteria yang dinyatakan dalam JIS A 5908:2003 telah berjaya dihasilkan dengan meunggunakan penangkap formaldehid dan rawatan kestabilan dimensi.

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

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