



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF ULTRA LOW FORMALDEHYDE EMISSION
PARTICLEBOARD USING A NEW MELAMINE-FORTIFIED UREA
FORMALDEHYDE RESIN**

LEE SENG HUA

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FORMALDEHYDE RESIN**



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of the requirement for the degree of Doctor of Philosophy

**DEVELOPMENT OF ULTRA LOW FORMALDEHYDE EMISSION
PARTICLEBOARD USING NEW MELAMINE-FORTIFIED UREA
FORMALDEHYDE RESIN**

By

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JUNE 2013

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An ultra low formaldehyde emission melamine-fortified urea formaldehyde (UF) resin with formaldehyde to urea molar ratio (F/U) as low as 0.88 was developed. Melamine-fortified resin yields a lower pH drop after addition of the hardener than UF resin and also causes a decrease of the hardening rate of the resin and, therefore, a lengthening of the hot press time is necessary. This study aimed to establish the optimum processing parameters to work with this resin in order to produce particleboard with formaldehyde emission and properties that comply with Japanese Industrial Standard (JIS). The processing parameters consist of shelling ratio of particles, pressing time and temperature. The tests for physical and mechanical properties were conducted in accordance with JIS A 5908:2003. Rubberwood served as the main raw material in this study. Oil palm trunk was used in the first stage of the experiment to examine its feasibility as an alternative raw material to replace conventional rubberwood. However, utilization of oil palm trunk failed to show convincing results. The ratio of 60% surface

particles and 40% core particles showed the best result in MOR and TS for the particleboard produced. The newly-developed resin worked well under pressing temperature of 180°C for 270 seconds. Despite the satisfied mechanical properties, particleboard made with this resin showed poor dimensional stability and failed to meet the JIS requirement. Optimization with different wax content and resin usage level was carried out to impart better dimensional stability upon the particleboard. The predicted values were obtained by running optimizer with the desirability function chosen to minimize the TS value. Based on the prediction results, the required TS value can be achieved by the application 1.47% of wax and 10:13% of resin which seem not practical from economic point of view. In addition, further addition of wax exceed 1% did not bring any worthwhile improvement on the dimensional stability of the particleboard. Regarding to the matter, heat treatment was carried out with intention to improve the dimensional stability of particleboard. Two treatment methods with treatment temperature ranged from 100°C to 200°C were conducted. Significant reduction in TS value occurred starting from the treatment temperature of 160°C with the methods involved re-press process. Finally, particleboard complied with all criterions stated in JIS A 5908:2003 was successfully produced by the combination of wax and resin optimization along with the heat treatment.

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

PEMBANGUNAN PAPAN SERPIHAN PERLEPASAN FORMALDEHID RENDAH DENGAN PENGGUNAAN PELEKAT UREA FORMALDEHID BARU YANG DIPERKAYAKAN DENGAN MELAMINE

Oleh

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Pelekat urea formaldehid (UF) perlepasan formaldehyde rendah diperkayakan dengan melamine yang mempunyai nisbah formaldehid kepada urea serendah 0.88 telah dibangunkan. Pelekat yang diperkayakan dengan melamine menyebabkan penurunan pH yang perlahan selepas penambahan ammonium klorida berbanding dengan pelekat resin biasa. Melamine juga menyebabkan penurunan kadar pengerasan pelekat baru ini, oleh itu, masa penekanan panas yang lebih panjang amat diperlukan. Kajian ini bertujuan untuk menubuhkan parameter pemprosesan yang optimum bagi menghasilkan papan serpihan yang memenuhi Japanese Industrial Standard (JIS) dari segi perlepasan formaldehid bersama dengan sifat-sifat mekanikal dan fizikal. Parameter pemprosesan yang disebut termasuk nisbah permukaan dan teras, bersama dengan masa dan suhu penekanan. Ujian terhadap sifat-sifat fizikal dan mekanikal dijalankan mengikut JIS A 5908:2003. Kayu getah merupakan bahan mentah yang utama dalam kajian ini. Kayu kelapa sawit digunakan dalam peringkat awal kajian untuk mengkaji potensinya sebagai

bahan mentah alternatif yang boleh mengganti kayu getah. Walaubagaimanapun, penggunaan kayu kelapa sawit gagal untuk memaparkan keputusan yang menyakinkan. Nisbah dengan 60% serpihan permukaan dan 40% serpihan teras menunjukkan keputusan terbaik bagi MOR and TS. Pelekat UF baru ini berfungsi baik di bawah suhu penekanan 180°C and masa penekan selama 270 saat. Walau sifat mekanikal adalah memuaskan, papan partikel yang dihasilkan dengan pelekat baru ini menunjukkan kestabilan dimensi yang lemah dan gagal memenuhi keperluan JIS. Pengoptimuman telah dijalankan dengan penggunaan kandungan lilin dan tahap penggunaan pelekat untuk meningkatkan kestabilan dimensi papan serpihan yang dihasilkan. Nilai ramalan diperolehi dengan penggunaan pengoptimasi yang berhasrat unutk meminimumkan nilai TS. Keputusan ramalan menyatakan bahawa nilai TS yang dikehendaki boleh diperoleh dengan penambahan 1.47% lilin dan 10:13% pelekat di mana penambahan tersebut kelihatan tidak praktikal dari segi ekonomi. Di samping itu, penambahan lilin melebihi 1% tidak membawa peningkatan kestabilan dimensi yang berbaloi. Mengenai masalah tersebut, rawatan haba telah dijalakan untuk meningkatkan kestabilan dimensi papan serpihan. Dua kaedah rawatan dengan suhu di antara 100°C and 200°C telah dijalankan. Pengurangan yang ketara berlaku mulai dari suhu 160°C dengan kaedah yang meglingkungi proses re-press. Akhirnya, papan serpihan yang memenuhi semua kriteria yang disebuti oleh JIS A 5908:2003 berjaya dihasilkan dengan menggabungkan pengoptimuman lilin dan pelekat dengan rawatan haba.

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I certify that a Thesis Examination Committee has met on **28 June 2013** to conduct the final examination of **Lee Seng Hua** on his thesis entitled "**Development of ultra low formaldehyde emission particleboard using a new melamine-fortified urea formaldehyde resin**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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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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Date: 28 JUNE 2013



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