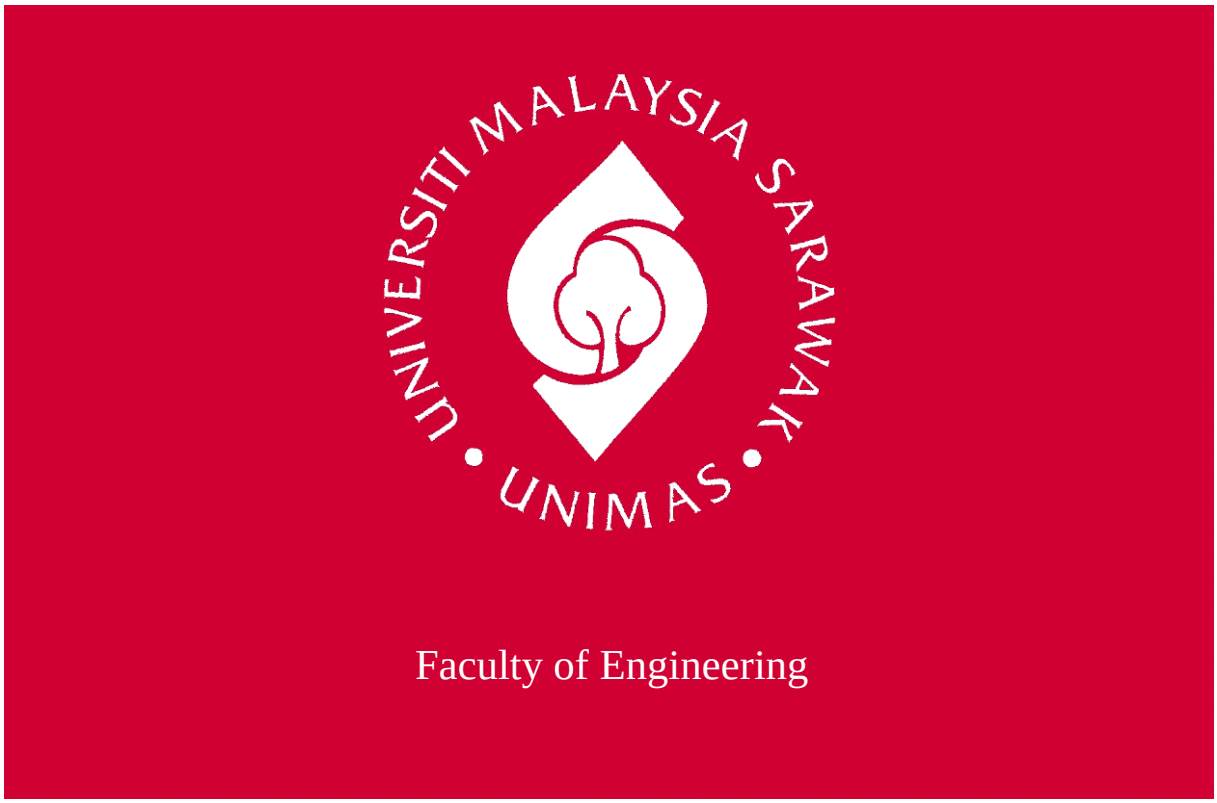

Physical, Mechanical and Thermal Properties of Sago Fiber Reinforced Composite Particleboard

Tay Chen Chiang

Doctor of Philosophy
2018

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report ☐

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Physical, Mechanical and Thermal Properties of Sago Fiber Reinforced Composite Particleboard

Tay Chen Chiang

A thesis submitted

In fulfilment of the requirements for the degree of Doctor of Philosophy

(Mechanical Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2018

DECLARATION

This is to certify that, the thesis work entitled " physical, mechanical and thermal properties of sago fiber reinforced composite particleboard " has been done by the candidate himself and does not contain any material extracted from elsewhere or from a work published by anybody else. The thesis has not been accepted for any degree and is not concurrently submitted in candidature for any other degree.

……..

Tay Chen Chiang
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Date : 12/12/2017

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ABSTRACT

In this research, sago particles with adhesive of low emission Urea Formaldehyde (UF) resin with 51.6% solid content are the main focus. The optimum performance of sago urea formaldehyde composite particleboard is determined. The fabrication process is based on JIS A 5908 standard. Sago residues have chemical reactivity with the matrix such as UF or phenol formaldehyde (PF) due to the lignocellulose composition.They are able to be hot-pressed into particleboard. The feasibility of hybrid particleboard made from sago mixed with waste wood was investigated. The processing and material parameters for an optimized board were identified based on the right particle size, weight fraction, density, matrix and hybrid while the effect of parameter was investigated through mechanical, physical and thermal analysis. The results showed composite particleboard with 800 kg/m^3 exhibited the optimum strength. The optimul mechanical properties were achieved at 80wt% of sago particles with particles size 1.18mm. Hybrid composite particleboard fabricated with ratio sago 25wt% and waste wood 75wt% able to improve the mechanical and physical propertie. The board performance was determined by the strength of the material, chemical bonding and its density. The interaction between particles depends on the particle and matrix bonding. The structure of the sago particleboard depends on the particle size, packing and the relative ratio. The sago particleboard met the requirement for ANSI A208.1-2009 as the door core, industrial and commercial purpose. The percentage of water absorption and thickness swelling increased with the weight fraction of particles. Composite particleboard made by PF has higher water absorption and thickness swelling compared with composite particleboard made by UF. The percentage of thickness swelling and water absorption can be reduced by impregnating higher loading of UF and PF. Sago UF/PF composite particleboard decomposed in single stage decomposition. The first step of decomposition is determination of moisture content while the

second step is dehydration reaction on the polymer chain and final step is residues conversion to carbon. Different Scanning Calorimetry (DSC) showed an endotherm peak between 50 ^{o}C – 100 ^{o}C which indicates the high amount of water molecules in the board. Generally, sago particles decomposed at 230 ^{o}C to 350 ^{o}C which indicated the loss of amorphous structure like hemicellulose, cellulose and lignin. The double endothermic peaks were due to the thermal decomposition of sago particles and filled with UF. Starch in the particleboard had contributed the high melting temperature due to cross-linking reaction between starch granules. Sample with single exotherm was found to be more thermally stable than those with multiple exothermal peaks. In hybrid particleboard, the addition of waste wood has improved the curing speed and better bonding between particles. Fourier transform infrared spectroscopy (FTIR) showed the bonding between functional group of sago particles and UF as well as the chemical interaction, which confirmed that the reactions between all the components in the composite system and thus, enhanced the mechanical strength of hybrid particleboard. A stable hydrogen bond was formed between UF and starch through chemical reaction. The scanning electron microscope (SEM) images showed that excellent dispersion of sago particles with matrix was important for stronger bonding. The better interfacial bonding and adhesion as well as reduction of micro-voids at the filler matrix interface occurred upon increasing of the matrix. SEM also showed the interaction between the sago particles and UF matrix was unsatisfactory due to particles debonding, particles pull-out, matrix fracture and particles damage occurred in sago UF particleboard.

Keywords: Sago composite particleboard, urea formaldehyde, physical and mechanical properties, thermal analysis.

Kestabilan Termal, Sifat-sifat Mekanikal dan Fizikal Komposit Papan Partikel Sagu

ABSTRAK

Dalam kajian ini, partikel sagu dengan pelekat resin urea-formaldehid (UF) dengan kandungan pepejal 51.6% adalah fokus utama dan prestasi optimum papan partikel sagu urea -formaldehid dikenalpastikan. Proses fabrikasi adalah berdasarkan Piawaian JIS A 5908. Sisa sagu yang mempunyai komposisi lignoselulosa bertindak balas secara kimia dengan matriks seperti UF atau PF (fenol-formaldehid) dan boleh menjalani proses "hot press". Kesesuaian sisa sagu dan kayu dicampur aduk menjadi papan hibrid telah dianalisis. Pemprosesan dan parameter bahan untuk papan yang mempunyai prestasi optimum telah dikenal pasti berdasarkan saiz partikel, pecahan berat, ketumpatan, matriks dan hibrid manakala kesan parameter diujikaji melalui analisa mekanikal, fizikal dan terma. Hasil kajian menunjukkan papan partikel dengan 800 kg/m^3 mempamerkan kekuatan optimum. Sifat mekanikal yang optimum dicapai pada kadar 80% berat zarah sagu dengan partikel bersaiz 1.18 mm. Papan partikel komposit hibrid yang dihasilkan dengan nisbah sagu 25% berat dan sisa kayu 75% berat mampu meningkatkan sifat mekanikal dan fizikal. Prestasi papan dipengaruhi oleh kekuatan bahan, komposisi kimia dan ketumpatan. Interaksi antara partikel bergantung kepada ikatan partikel dan matriks. Struktur papan partikel sagu bergantung kepada saiz partikel, kepadatan dan nisbah relatif. Papan partikel sagu telah memenuhi syarat piawaian ANSI A208.1-2009 sebagai teras pintu untuk tujuan industri dan komersial. Keputusan ujikaji menunjukkan bahawa peratusan penyerapan air dan pengembangan ketebalan bertambah dengan peningkatan pecahan berat partikel. Partikel yang diperbuat daripada PF mempunyai penyerapan air dan pemgembangan ketebalan lebih tinggi berbanding partikel diperbuat daripada UF. Peratusan pengembangan ketebalan dan

penyerapan air boleh dikurangkan dengan menggunakan peratusan UF dan PF yang lebih tinggi. Papan sagu UF/PF mereput dalam penguraian peringkat tunggal. Langkah pertama penguraian adalah penentuan kandungan lembapan manakala langkah kedua adalah tindak balas dehidrasi pada rantai polimer dan langkah terakhir melibatkan penukaran sisa kepada karbon. Kalorimetri Imbasan Perbezaan (DSC) menunjukkan puncak endotermik pada 50 ^{o}C-100 ^{o}C yang menunjukkan papan partikel sagu UF/PF mengandungi jumlah molekul air yang banyak. Secara umumnya, partikel sagu mereput antara 230 ^{o}C-350 ^{o}C dan ini menunjukkan bahawa kehilangan struktur amorfus seperti hemiselulosa, selulosa dan lignin. Puncak gandaan endotermik adalah disebabkan oleh penguraian terma zarah sagu dan dipenuhi oleh UF. Sampel dengan eksoterma tunggal lebih stabil daripada sampel yang mempunyai pelbagai puncak eksoterma. Penambahan sisa kayu dalam papan hibrid telah meningkatkan kelajuan pengawetan dan ikatan antara partikel. Spektroskopi Inframerah Fourier (FTIR) menunjukkan ikatan antara kumpulan berfungsi partikel sagu dan UF serta interaksi kimia. Ini mengesahkan tindak balas antara semua komponen dalam sistem komposit dan ini meningkatkan kekuatan mekanikal bagi papan partikel jenis hibrid. Mikroskop Pengimbasan Elektron (SEM) menunjukkan bahawa penyebaran partikel sagu dengan matriks adalah penting untuk pembentukan ikatan yang kuat dalam sistem komposit. Ikatan dan lekatan antara permukaaan papan menjadi lebih baik dan lebih banyak pengurangan ruang kosong mikro di pengisi matriks apabila peratusan matriks ditingkatkan. SEM juga menunjukkan interaksi antara partikel sagu dan UF matriks adalah kurang memuaskan disebabkan oleh zarah nyahikatan, partikel tercabut, kerosakkan matriks dan partikel yang telah wujud dalam komposit.

***Kata kunci**: Papan komposit sago, urea-formaldehid, sifat-sifat fizikal and mekanikal, analisis haba.*

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