UNIVERSITI PUTRA MALAYSIA

PHYSIO-CHEMICAL AND MECHANICAL PROPERTIES OF DIFFERENT MORPHOLOGICAL PARTS OF SUGAR PALM FIBRE REINFORCED POLYESTER COMPOSITES

SAHARI BIN JAPAR

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By

SAHARI BIN JAPAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

April 2011
DEDICATIONS

For all your advice and encouragement, this thesis is gratefully dedicated to my beloved parent, family and my friends. Thank you very much for your continuous support and effort towards the publication of this thesis.
Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

PHYSIO-CHEMICAL AND MECHANICAL PROPERTIES OF DIFFERENT MORPHOLOGICAL PARTS OF SUGAR PALM FIBRE REINFORCED POLYESTER COMPOSITES

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SAHARI BIN JAPAR

April 2011

Chairman : Professor Mohd Sapuan Salit, PhD, P. Eng
Institute : Institute of Advanced Technology

Recently, due to increase environmental concerns, scientists and technologists have placed much importance on the application of natural fibre composites especially in biocomposites. The purpose of this research is to study the properties of single fibre from different morphological parts of sugar palm tree and properties of sugar palm fibre from different parts reinforced unsaturated polyester composites. These studies have been done in order to evaluate the potentiality of fibre from different morphological parts of sugar palm tree i.e sugar palm frond (SPF), sugar palm bunch (SPB), sugar palm trunk (SPT) and black sugar palm fibre (ijuk) as which is can be used as eventual raw materials for the reinforcement of polymer matrix composites which are suitable in various applications such as building, automotive, furniture and packaging.

The tensile, chemical and physical properties of single fibres from all parts were evaluated. The results showed that the highest tensile strength and tensile modulus were obtained from the SPF followed by SPB, ijuk and SPT. These results have been proven with the results of their chemical compositions where the highest cellulose content was obtained from SPF (66.49%) and followed by SPB (61.76%), ijuk
(52.29%), and SPT (40.56%).

The mechanical and physical properties of natural fibres from different parts of sugar palm tree reinforced unsaturated polyester composites which are SPF/PE, SPB/PE, SPT/PE and ijuk/PE have also been evaluated in this study. For tensile strength analysis, it is found that SPF/PE shared the higher value of 15.179 MPa (±2.425) followed by SPB/PE, ijuk/PE and SPT/PE with 12.809 MPa (±1.580), 11.473 MPa (±0.536) and 9.817 MPa (±1.890) respectively. The higher value of flexural strength and flexural modulus obtained from SPT/PE with the value of 41.906 MPa and 3.363 GPa respectively. For impact strength analysis, similar trends were found with the tensile stress and tensile strain results and SPF/PE showed the higher value of impact strength (8.091 kJ m⁻²) followed by SPB/PE, ijuk/PE and SPT/PE. In cases of physical properties, it is found that SPF/PE showed the higher value of water absorption and thickness swelling with the value of 1.57%, and 1.56% followed by SPB/PE (1.35%, 1.11%), ijuk/PE (0.65%, 0.76%) and SPT/PE (0.39%, 0.50%). Scanning electron microscopy (SEM) test were carried out after the mechanical test to observe the interface bonding of fibre and matrix.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SIFAT-SIFAT FISIO-KIMIA DAN MEKANIKAL KOMPOSIT POLIESTER DIPERKUAT GENTIAN DARIPADA BAHAGIAN POKOK ENAU YANG BERBEZA

Oleh

SAHARI BIN JAPAR

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Baru-baru ini, disebabkan peningkatan keperihatinan terhadap alam sekitar, saintis dan teknologis menekankan terlalu banyak kepentingan terhadap penggunaan gentian semula jadi khususnya dalam biokomposit. Tujuan penyelidikan ini ialah untuk mengkaji sifat-sifat gentian tunggal daripada bahagian morfologi pokok enau yang berbeza dan sifat-sifat komposit poliester tak tepu diperkuat gentian daripada bahagian pokok enau yang berbeza. Kajian ini dilaksanakan untuk menilai potensi gentian daripada bahagian morfologi pokok enau yang berbeza iaitu pelepah pokok enau (SPF), tandan pokok enau (SPB), batang pokok enau (SPT) dan gentian hitam pokok enau (ijuk) sebagai bahan asas untuk memperkuatkan komposit polimer yang sesuai dalam pelbagai aplikasi seperti bangunan, automatif, perabot dan pembungkusan.

Sifat-sifat ketarikan, kimia dan fizikal bagi gentian tunggal daripada bahagian yang berlainan dinilai. Keputusan menunjukkan bahawa kekuatan tarik dan modulus tarik yang paling tinggi diperolehi daripada SPF diikuti oleh SPB, ijuk dan SPT. Keputusan ini dibuktikan oleh keputusan komposisi kimia dimana kandungan
selulosa yang paling tinggi diperolehi daripada SPF (66.49%) dan diikuti oleh SPB (61.76%), *ijuk* (52.29%) dan SPT (40.56%).

Sifat-sifat mekanikal dan fizikal komposit polyester tak tepu diperkuat gentian daripada bahagian pokok enau yang berbeza iaitu SPF/PE, SPB/PE, *ijuk*/PE dan SPT/PE juga dinilai dalam penyelidikan ini. Untuk analisis kekuatan tarik, didapati bahawa SPF/PE menunjukkan nilai yang tertinggi iaitu 15.179 (±2.425) diikuti oleh SPB/PE, *ijuk*/PE dan SPT/PE dengan masing-masing bernilai 12.809 MPa (±1.580), 11.473 MPa (±0.536) dan 9.817 MPa (±1.890). Nilai kekuatan lentur dan modulus lentur yang tertinggi diperolehi daripada SPT/PE iaitu 41.906 MPa and 3.363 GPa. Bagi analisis kekuatan tumbuk, urutan yang sama diperolehi daripada keputusan tekanan tarik dan renggangan tarik iaitu SPF/PE menunjukkan nilai yang paling tinggi dengan nilai 8.091 kJ m⁻² diikuti oleh SPB/PE, *ijuk*/PE dan SPT/PE. Sementara untuk sifat fizikal, didapati bahawa SPF/PE menunjukkan nilai penyerapan air dan pembengkakan tebal yang paling tinggi iaitu 1.57%, dan 1.56% diikuti oleh SPB/PE (1.35%, 1.11%), *ijuk*/PE(0.65%, 0.76%) dan SPT/PE (0.39%, 0.50%). Ujian imbasan mikroskop elektron (SEM) dilakukan selepas ujian mekanikal untuk melihat antara muka gentian dan matriks.
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I certify that a Thesis Examination Committee has met on 04 April 2011 to conduct the final examination of Sahari Japar on his thesis entitled "Physio-chemical and mechanical properties of different morphological parts of sugar palm fibre reinforced polyester composites" 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 Master of Science.

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Date:
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.

______________________________
SAHARI BIN JAPAR

Date: 4 April 2011
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LIST OF ABBREVIATIONS

A.D  air dry
ASTM American Society for Testing and Material
CO₂  Carbon dioxide
FTIR  Fourier transform infrared spectroscopy
INTROP Tropical Forestry and Forest Products
KBr  Potassium bromide
KFUPC Kenaf fibre unsaturated polyester composites
MEKP Methyl ethyl ketone peroxide
NaOH Sodium hydroxide
OW   Oven dry weight
PE   Unsaturated polyester
PET  Polyethylene terephthalate
PP   Polypropelyne
PVC  Polyvinyl chloride
SEM  Scanning electron microscope
SPB  Sugar palm bunch
SPF  Sugar palm frond
SPT  Sugar palm trunk
TAPPI Technical Association of the Pulp and Paper Industry.
WA   Water absorbed
WW   Wet weight
NOMENCLATURE

\( \rho \)  
density of fibre (g/cm \(^3\))

\( m \)  
mass of fibre (g)

\( V \)  
volume of water (cm \(^3\))

\( S_t \)  
tensile strength of test specimen (MPa)

\( F \)  
pulling force applied on test specimen (kN)

\( A \)  
cross section area of test specimen (mm \(^2\))

\( E \)  
tensile modulus of test specimen (MPa)

\( \sigma \)  
stress applied on test specimen (MPa)

\( \varepsilon \)  
strain of test specimen (mm/mm)

\( \sigma_{\text{max}} \)  
flexural strength (MPa)

\( E_H \)  
flexural modulus (MPa)

\( R \)  
rate of crosshead motion, mm/mm

\( L \)  
support span, mm

\( Z \)  
rate of straining of the outer fibre, mm/mm/min; \( Z \) shall equal 0.01

\( P \)  
load at yield (maximum load)

\( L \)  
support span (mm)

\( b \)  
width (mm)

\( d \)  
thickness (mm)
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