



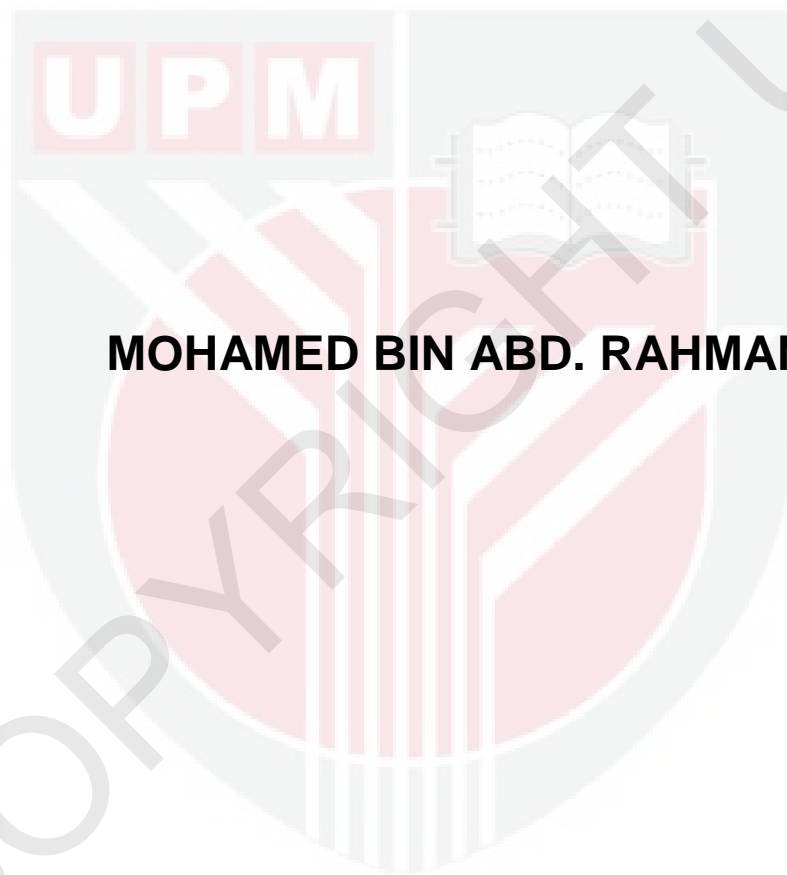
UNIVERSITI PUTRA MALAYSIA

**PHYSICAL, MECHANICAL AND THERMAL PROPERTIES OF PINEAPPLE
LEAF FIBERS AND PALF-REINFORCED VINYL ESTER COMPOSITES**

MOHAMED BIN ABD. RAHMAN

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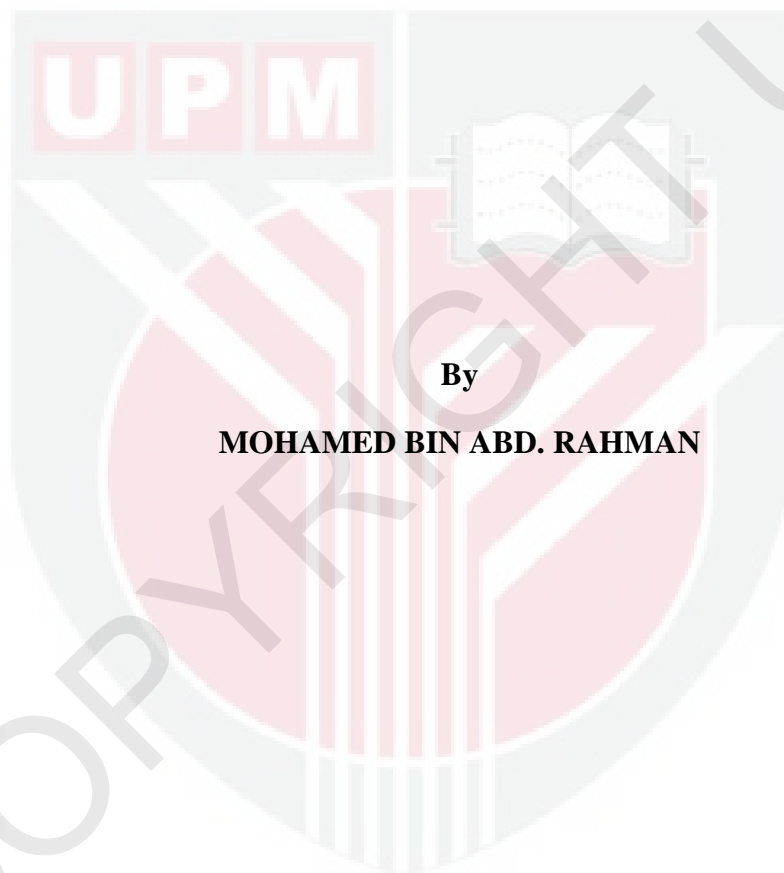


MOHAMED BIN ABD. RAHMAN

**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA**

2010

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PINEAPPLE LEAF FIBERS AND PALF-REINFORCED VINYL ESTER
COMPOSITES**



By

MOHAMED BIN ABD. RAHMAN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

September 2010

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

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September 2010

Chairman : Professor Mohd. Sapuan bin Salit, PhD, PEng

Faculty : Engineering

Despite being mechanically and environmentally sound, pineapple leaf fibers (PALF) are the least studied natural fibers especially as reinforcement in polymer composites and currently of little use in Malaysia. As the industrial importance and plantation area increase, efforts to develop applications utilizing PALF and simultaneously reduce environmental pollution must be carried out. This thesis aimed to contribute by studying a few fundamental aspects of PALF and PALF-reinforced composites. As species strongly dictates natural fiber properties, PALF from the three most popular Malaysian cultivars were characterized physically, mechanically and thermally. Effects of a simple abrasive combing and pretreatments on PALF properties were evaluated. PALF were used to reinforce vinyl ester resin (VER) using liquid composite molding (LCM) and the composite properties compared with those of hand-laid neat VER, glass fiber and PALF-VER composites. A factorial study was carried out on the effects and interactions of catalyst amount and selected process parameters on the properties of LCM VER sheets. Influence of fiber diameter, fiber property-retention after long storage, simple pretreatments, fiber location on the leaves and fiber separation techniques on mechanical properties

of PALF-VER composites were also investigated. PALF tensile strength fits well with two-parameter Weibull distribution. Though uncritical for PALF-thermoset composites, the 20°C difference in thermal stability of PALF of different varieties is significant for PALF-thermoplastic composites. Josapine cultivar is the most appropriate PALF species in terms of potential fiber quantity, fineness, high tensile strength and modulus, thermal stability and ease of extraction. Vascular bundles and fiber strands were similar chemically and structurally thus differed by diameter only. The former were effectively stronger due to the presence of bonding tissues. Bundles from different locations in the leaves and those stored for a six-month period in hot humid conditions may be used without significantly affecting composite mechanical properties. At low weight fraction and consolidating pressure, PALF regardless of diameters and locations performed equally well in enhancing flexural properties in static loading. Composite toughness was higher when fine strands were used. Washing PALF with water improved PALF-VER adhesion while prolonged soaking produced no extra benefits. PALF and PALF-VER adhesion were not improved with the use of dilute aqueous sodium hypochlorite solution. Abrasive combing viably separated and produced fine and clean PALF of reasonable properties. Abrasive-combed PALF equaled technical fibers in reinforcing VER while their lower ductility reduced composite toughness. Untreated PALF bundles may be used to reinforce VER to produce real composites using LCM with water resistance significantly enhanced by molding pressure. Judicious process parameter selection is required to produce quality VER sheets and by extension PALF-VER composites. Molding VER-unsaturated polyester blend resulted in a significantly different material and a potential matrix for PALF composites.

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

**SIFAT FIZIKAL, MEKANIKAL DAN TERMAL GENTIAN DAUN NENAS
DAN KOMPOSIT VINIL ESTER YANG DIPERKUAT DENGAN GDN**

Oleh
MOHAMED BIN ABD. RAHMAN
September 2010

Pengerusi : Professor Mohd. Sapuan bin Salit, PhD, PEng

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Walaupun GDN amat baik dari segi mekanikal dan untuk alam sekitar, ianya amat sedikit dikaji terutamanya sebagai peneguh dalam komposit polimer serta kurang digunakan di Malaysia. Dengan peningkatan kepentingan industri serta kawasan penanaman nanas, usaha membangunkan aplikasi menggunakan GDN sekaligus mengurangkan pencemaran alam mesti dilaksanakan. Tesis ini menyumbang ke arah ini melalui pengkajian beberapa aspek asas GDN dan komposit polimer-GDN. Kerana kultivar faktor terpenting menentukan sifat gentian, GDN dari tiga kultivar nanas paling popular di Malaysia diuji sifat-sifat fizikal, mekanikal dan termal mereka. Kesan penggunaan sikat lelas dan rawatan awalan mudah ke atas sifat GDN juga dikaji. GDN digunakan bagi mengukuh damar vinil ester (VER) menggunakan pembikinan komposit cecair dengan mampatan (LCM) dan sifat komposit terhasil dibandingkan dengan sifat damar serta komposit menggunakan GDN dan gentian kaca diperbuat secara manual. Kajian faktorial dijalankan ke atas kesan dan interaksi di antara kandungan pemangkin dan parameter proses pada sifat kepingan VER dihasilkan melalui LCM. Sifat mekanikal komposit VER-GDN dikaji untuk mengenalpasti kesan garispusat GDN, tempoh simpanan, rawatan awalan, lokasi GDN pada daun serta teknik pemisahan gentian. Daya regangan GDN berpadanan

dengan distribusi Weibull dua parameter. Meskipun tidak kritikal untuk komposit GDN-termoset, perbezaan 20°C dalam kestabilan termal GDN dari pelbagai kultivar sangat signifikan untuk komposit GDN-termoplastik. Spesies Josapine adalah GDN paling sesuai dari aspek kuantiti gentian, kehalusan, sifat regangan, kestabilan termal dan kemudahan ekstraksi. GDN kasar dan halus didapati sama dari segi struktur dan kimia serta dibezakan oleh garispusat sahaja. Kekuatan GDN kasar lebih efektif dengan kehadiran ikatan tisu-tisu. GDN dari lokasi berbeza pada daun serta yang disimpan selama enam (6) bulan pada suhu dan kelembapan tinggi boleh digunakan tanpa mempengaruhi sifat mekanikal komposit secara signifikan. Pada jumlah kecil dan tanpa mampatan, GDN tanpa mengira lokasi dan garispusat sama baiknya dalam meningkatkan lenturan komposit bagi bebanan statik. Ketangguhan komposit lebih tinggi jika diperkuat dengan GDN halus. Pencucian GDN dengan air meningkatkan adhesi GDN-VER tapi tiada manfaat tambahan pada rendaman berpanjangan. GDN dan adhesi GDN-VER tidak diperbaiki dengan penggunaan larutan cair natrium hipoklorit. Sikat lelas berpotensi menghasilkan gentian halus dan bersih dengan sifat-sifat yang baik. GDN yang disikat-lelas setara GDN halus dalam menguatkan VER dalam aplikasi statik manakala sifat senang putus mereka mengurangkan ketangguhan komposit. GDN kasar tidak dirawat boleh digunakan untuk menghasilkan komposit VER secara LCM di mana sifat ketahanan air komposit meningkat secara signifikan hasil penggunaan mampatan. Pilihan bijak parameter proses perlu bagi mendapatkan kepingan VER dan komposit VER-GDN berkualiti. Tuangan campuran VER-poliester menghasilkan satu bahan dengan sifat-sifat yang berlainan berpotensi digunakan sebagai matrik untuk komposit GDN.

ACKNOWLEDGEMENTS

I am pleased to express my profound gratitude and appreciation to my honorable supervisor, Professor Ir. Dr. Mohd. Sapuan Salit, Professor of Composites and Head of Department, Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, for his constant supervision, encouragement and wise advice throughout my entire study period. Special thanks are also due to my co-supervisors, Professor Dr. Shahjahan Mridha, Department of Manufacturing and Materials Engineering, Kulliyyah of Engineering, International Islamic University Malaysia and Dr. Khalina Abdan, Institute of Tropical Forest and Forest Products (INTROP), Universiti Putra Malaysia, for their support and constructive comments throughout this trying period.

I wish to extend my thanks to all my colleagues in the Composite Group working under Professor Ir. Dr. Mohd. Sapuan Salit for information and knowledge shared. Invaluable assistance received from the personnel of the Malaysian Pineapple Industry Board (MPIB) was equally appreciated. I am indebted to Mr. Zulkafli Abdullah, Madam Norisah and Mr. Nordin Hassan for providing me with pineapple leaves for PALF extraction as well as sharing their motivating experiences. Various assistance and support received from Mr. Syamsul Kamal Arifin, Mr. Ibrahim Razali, Mr. Mohd. Hairi Mohd. Rasit, Mr. Muhammad Noor Zainal Abidin, Mr. Mohd. Faisal Room and Mr. Ahmad Rahimie Awang from the Kulliyyah of Engineering, International Islamic University Malaysia and Mr. M. Wildan Ilyas M. Ghazali from the Faculty of Engineering and Mr. Syahrul Hilmi Palahudin and Mr.

M. Lufti M. Tawil from INTROP, Universiti Putra Malaysia in carrying out numerous tests required throughout the study are amply appreciated. Thanks are also due to the International Islamic University Malaysia for providing me with the study leave to carry out this research and the Malaysian Government for the financial support.

I am especially indebted to my late father, Mr. Abd. Rahman Yahya, from whom I learned many invaluable lessons in life and to my most loved mother, Madam Hamidah Imam Bahsah, from whom I got the inspiration to work on PALF. Many special thanks are due to my wife, Madam Normalely Othman for her constant support and help and my children, Luqman Hafidz and Fathimah Zahrah for their assistance and ideas. They were always there when I needed them. I will never be able to express all my gratitude to all that contributed in various ways. Thanks to all my friends and well-wishers for their encouragement which inspired me to complete the assignment.

I certify that a Thesis Examination Committee has met on the 28th of September 2010 to conduct the final examination of Mohamed Bin Abd. Rahman on his thesis entitled “Physical, Mechanical and Thermal Properties of Pineapple Leaf Fibers and Palf-reinforced Vinyl Ester Composites” in accordance with the Universities and Universiti College Act 1971 and the Constitution of 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 any other institutions.

MOHAMED BIN ABD RAHMAN
Date: 28 September 2010

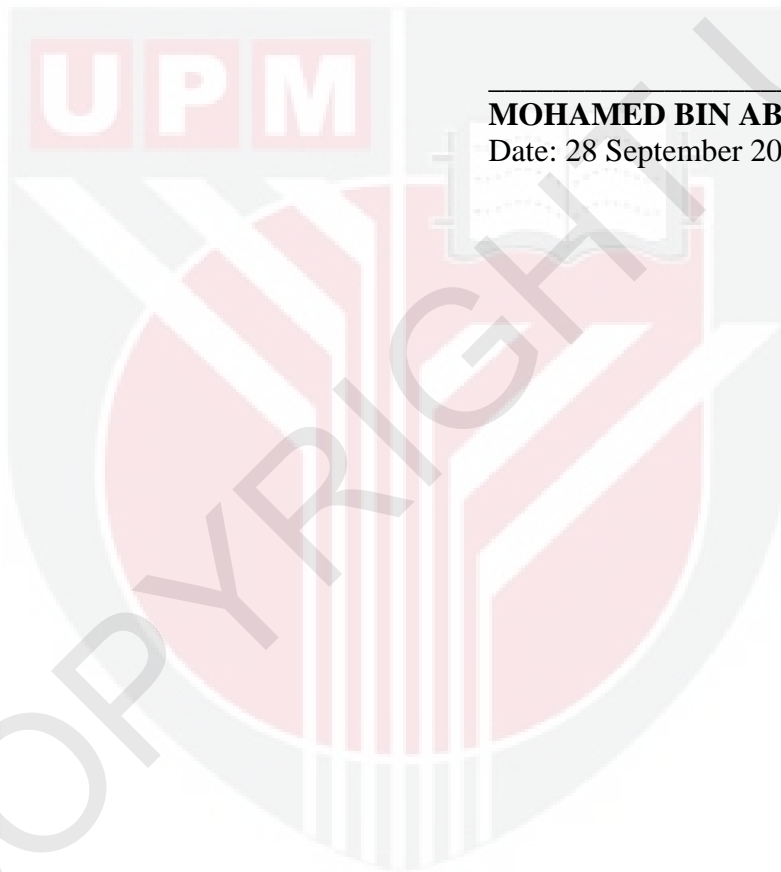


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