



**UNIVERSITI PUTRA MALAYSIA**

**MECHANICAL CHARACTERISATION OF SAWDUST AND CHIPWOOD-  
FILLED EPOXY COMPOSITE**

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**FK 2008 29**



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COMPOSITE**

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**MASTER OF SCIENCE  
UNIVERSITI PUTRA MALAYSIA**

**2008**



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FILLED EPOXY COMPOSITE**

**By**

**NORHISHAM BIN SEYAJAH**

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

**February 2008**



*Very grateful to ALLAH for  
The blessing  
To my family and everyone  
Involved in my life,  
Thank you.....*

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of master of science.

**MECHANICAL CHARACTERISATION OF SAWDUST AND CHIPWOOD-FILLED EPOXY COMPOSITE**

By

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**February 2008**

**Chairman : Associate Professor Datin Napsiah Ismail, Ph.D**

**Faculty : Engineering**

Natural fibre are increasingly being used as reinforcement in commercial thermoset due to their low cost and renewable nature. In this research the composite of epoxy with sawdust and chip wood untreated wood fibre content 14% by weight as a filled were studied and waste wood obtained from the timber industry.

The highest tensile strength valued for sawdust is 28.917 MPa and chip wood is 21.951 MPa, compare with epoxy if self is 16.307 MPa. Meanwhile the highest flexural strength values for sawdust is 0.468 MPa, and chip wood is 0.596 MPa, compare with epoxy it self is 0.645 MPa.

However in addition the good trend in elongation at break of epoxy composite with sawdust and chip wood due to the dispersion of the individual fibre as the fibre contents was different size in the matrix. It is also that some matrix materials adhere to the surface of the pull out fibre indicating a good bond and interfacial adhesion between the matrix and the fibre.



Further testing, using scanning electron microscopy (SEM) micrographs on tensile of sawdust epoxy composite showed very little fibre pull out and splitting, and for tensile of chip wood epoxy composite showed although there is a bigger contact surface between filler and matrix but the adhesion is no good. Meanwhile the flexural of sawdust epoxy composite showed the poor adhesion and there are a void around the sawdust particle, and for flexural of chip wood epoxy composite showed cavities clearly indicate the poor interfacial adhesion between the epoxy matrix polymer.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan bagi ijazah Master Sains

**SIFAT-SIFAT MEKANIKAL BAGI HABUK KAYU DAN SERPIHAN KAYU-  
PENGISI EPOKSI KOMPOSIT**

Oleh

**NORHISHAM SEYAJAH**

**Februari 2008**

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Penggunaan gentian semulajadi semakin meningkat sebagai bahan penguat dalam komersial termoset disebabkan harganya yang rendah serta bahan ini boleh diperbaharui. Pada kajian ini epoksi komposit diperkuat dengan serbuk kayu dan serpihan kayu yang tidak dilakukan sebarang perawatan sebagai pengisi dimana kandungan gentian kayu sebanyak 14% mengikut berat dikaji, bahan sisa kayu ini diperolehi dari industri perkayuaan.

Kekuatan tensil untuk habuk kayu bernilai 28.917 MPa, manakala untuk serpihan kayu pula bernilai 21.951 MPa, jika dibandingkan dengan epoksi komposit tanpa gentian hanya 16.307 MPa. Pada masa yang sama kekuatan fleksural untuk habuk kayu pula bernilai 0.468 MPa, dan untuk serpihan kayu pula bernilai 0.596 MPa, jika dibandingkan dengan epoksi komposit tanpa gentian bernilai 0.645 MPa.

Walaupun sebagai tambahan pemanjangan pada takat putus untuk epoksi komposit pengisi dengan serbuk kayu dan serpihan kayu menunjukkan petanda arah

yang baik disebabkan penyerakkan gentian secara individu sebagai kandungan gentian pada ukuran yang berbeza didalam matriks. Pada masa yang sama juga ada sebahagian matriks yang masih melekat pada permukaan gentian yang tercabut keluar, ini menunjukkan ikatan yang baik dan juga lekatan diantara permukaan yang menjadi sempadan bersama antara dua iaitu matriks dan gentian.

Kajian seterusnya, menggunakan scanning electron microscope (SEM) micrographs pada tensil serbuk kayu epoksi komposit menunjukkan sedikit gentian tertarik keluar serta merekah, manakala pada tensil serpihan kayu epoksi komposit pula menunjukkan walaupun terdapat permukaan cantuman yang besar diantara pengisi dengan matrik, lekatannya kurang baik kerana terdapat retakan serta ruang kosong diantar dua permukaan. Dalam pada masa yang sama untuk fleksural pada serbuk kayu epoksi komposit menunjukkan serbuk kayu yang tidak dirawat memberikan kesan lekatan yang kurang baik kerana terdapat rongga disekeliling partikel serbuk kayu, manakala untuk fleksural pada serpihan kayu epoksi komposit menunjukkan dengan jelas terdapat rongga dimana menandakan kelemahan antara muka diantara epoksi matriks polimer.



## ACKNOWLEDGEMENT

PRAISE and THANKS belong only to ALLAH S.W.T for giving me the time to work with the following wonderful people and friends' through-out the course of this study. In chronological order of appearance, they are as mention below.

The author wishes to express his sincere appreciation and gratitude to his supervisor committee, Datin Dr. Napsiah Binti Ismail, for her supervise, constructive, criticism and advice throughout the course of this project. Her taking some time out of her busy schedule to supervision and guidance have indeed been very helpful and invaluable.

Author also would like to record his tremendous thanks to his supervisor committee, Dr. Safuan Bin Salit for his comments and suggestions in the preparation of this project.

A tremendous thanks are extended special to UPM laboratory technicians, En Weldan, En Roshidi and En Mior, for allowing and providing the facilities to be used to success the research study. Who helped author in many ways, to author friend Edy Syam who always ready to listen and motivating author to accomplish the research. To Sulik (the consultant of Tan Chong Transportation), Zuraidah (on the statistical analysis), Mr. Ann and Mr Choong ( who are the supplier of raw material) in helping the author to get materials for this project. Without these essential materials there would not be any success.



Special dedication and deep appreciation to writer's beloved wife, Nor'aini Binti Tahir, his son, Mohd Alif Naquidduin, Mohamad Iqmal Hakim, Mohammad Afiq Danial and his daughter, Nur Atiqah Alya for their patience, encouragement and assistance during the difficult period and construct prayer for the writer success have indeed been a source of inspiration. ALHAMDULILLAH.

I certify that an Examination Committee met on \_\_\_\_\_ to conduct the final examination of Norhisham Bin Seyajah on his Master of Science thesis entitled “Investigation on the mechanical characteristics of sawdust and chip wood filled epoxy” in accordance with University Putra Malaysia (Higher Degree) Act 1980 and Universiti Putra Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the (Name of relevant degree).

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Date: 10 July 2008



## **DECLARATION**

I declare that the thesis is my original work expect 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.

---

**NORHISHAM BIN SEYAJAH**

Date: 26 February 2008

## TABLE OF CONTENTS

	<b>Page</b>
<b>DEDICATION</b>	ii
<b>ABSTRACT</b>	iii
<b>ABSTRAK</b>	v
<b>ACKNOWLEDGEMENTS</b>	vii
<b>APPROVAL</b>	ix
<b>DECLARATION</b>	xi
<b>LIST OF TABLE</b>	xv
<b>LIST OF FIGURES</b>	xvii
<b>LIST OF ABBREVIATIONS</b>	xx
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Background	1
1.2 Statement of problem	6
1.3 Research objective	8
1.4 Thesis organization	8
<b>2 LITERATURE REVIEW</b>	<b>10</b>
2.1 Composite	10
2.1.1 Advantages of composite	14
2.1.2 Disadvantages of composite	14
2.2 Classification type of composite materials	15
2.2.1 Natural composite materials	16
a) Wood or timber	17
b) Cellulose	17
c) Lumber	18
2.2.2 Synthetic Composite	19
2.3 Type of Composites	19
2.3.1 Reinforcements	19
2.3.2 Man-made reinforcements	21
2.4 Fiber	22
2.5 Type of fiber	24
2.5.1 Natural fiber	25
2.5.2 Water absorption	27
2.5.3 Synthetic fiber	29
a) Glass fiber	30
b) Boron fiber	30
c) Carbon fiber	31
d) Aramid fiber	32
2.6 Important fiber type	33
2.7 Cross sectional shape and surface roughness	34
2.8 Matrices	35



2.9	Thermosets	39
2.9.1	Epoxy resins	39
2.10	Method of making composite material	43
2.10.1	Hand-lay-up	44
2.10.2	Spray-up	45
2.10.3	Filament winding	46
2.11	Wood plastic composite	47
2.11.1	Process	48
2.11.2	Classification of wood composite	50
2.11.3	Particle composite	50
2.11.4	Fiber composite	51
2.12	Wood machining process	52
2.12.1	Saw blade	54
2.12.2	Saw dust	55
2.12.3	Chip formation	56
2.12.4	Chip type	57
2.13	Type of Machine Testing	60
2.15	Summary	60
<b>3</b>	<b>MATERIAL AND METHODS/METHODOLOGY</b>	<b>64</b>
3.1	Introduction	64
3.2	Material preparation and equipment	65
3.2.1	Saw dust and Chip Wood Category	65
3.2.2	Laboratory test methods	66
3.3	Raw Materials	67
3.4	Preparation of composite specimens	67
	a) filler	68
	b) Epoxy Resin and Hardener	69
	c) Mold	69
3.5	Specimens of composite	69
3.5.1	The Basic blend Composition	72
3.5.2	The Fiber and Raw Materials Composite	73
3.5.3	Tensile Testing ASTM D 638	74
3.5.4	Flexure Testing ASTM D 790-79	75
3.5.5	Instron Machine	77
3.6	Morphological properties	79
3.7	Type of Analysis	79
	a) T- test	80
	b) Analysis of Variance (ANOVA)	80
3.8	Conclusion	81
<b>4</b>	<b>RESULTS AND DISCUSSION</b>	<b>82</b>
4.1	Measures of differences of Mean Scores for all Properties	82
4.2	Comparisons of the mean of each property among the size of particle of SW/Epoxy resin (Tensile Test)	84
4.3	Comparisons of the mean of each property among the size of particle for CW/Epoxy resin	85

	(Tensile Test)	
4.4	Comparisons of the mean of each property among the size of particle for SD/Epoxy resin (Flexural Test)	86
4.5	Comparisons of the mean of each property among the size of particle for CW/Epoxy resin (Flexural Test)	86
4.6	Modulus of Rapture MOR and Modulus of Elasticity MOE	87
4.6.1	Comparisons of the mean of MOR each property among the size of particle SD and CW/Epoxy resin (Flexural Test)	87
4.6.2	Comparisons of the mean of MOE each property among the size oparticle SD and CW/Epoxy resin (Flexural Test)	90
4.7	Morphological Properties of flexural and tensile	92
4.8	Tensile Properties	93
4.9	Flexural Properties	101
<b>5</b>	<b>CONCLUSIONS AND RECOMMENDATIONS</b>	
5.1	Conclusions	109
5.2	Recommendation for future work	113
	<b>REFERENCES</b>	115
	<b>APPENDICES</b>	123
	<b>BIODATA THE STUDENT</b>	146



## List of Table

<b>Table</b>	<b>Page</b>
2.1 Advantages of Composite	14
2.2 Disadvantages of Composite	15
2.3 Type of Composite	19
2.4 Mechanical properties of natural fibres as compared to conventional reinforcing fibres (Bledzki and Gassan,1999).	26
2.5 Some important characteristics of epoxy (Chawla, 1998).	41
2.6 composition of widely used epoxy matrix system (Campbell, 2004).	42
2.7 The advantages of Epoxy resin and Hardener ASASIN 142 A/B	42
2.8 Classification of Wood Composites	50
3.1 Table 3.1 Basic Group of Fiber/Epoxy composite with 14wt % fiber loading and various type of fiber	72
4.1 Result of tensile test	84
4.2 Result of flexural test	84
4.3 Comparisons of the mean of each property among the level of sawdust	85
4.4 Comparisons of the mean of each property among the level of CW	85
4.5 Comparisons of the mean of each property among the level of sawdust	86
4.6 Comparisons of the mean of each property among the level of chip wood	87
4.7 The Means of MOR For Sawdust and Chip wood	88
4.8 Independent T-test for Mean MOR between type of fiber	88



4.9	Comparisons of the mean of MOR among the size of particle	89
4.10	The Means of MOE For Sawdust and CW	90
4.11	Independent T-test For Mean MOE Between Type of Fiber	91
4.12	Comparisons of the mean of MOE among the size of particle	92



## List of Figures

Figure		Page
2.1	Section through a tree trunk	17
2.2	The compilations of fiber pattern at reinforce composite materials Weeton (1987).	24
2.3	Classification of fiber based on natural and synthetic fibers	24
2.4	Fibers can have a variety of cross sectional shapes, although most fibers have a more or less circular cross-section.	35
2.5	Hand lay-up process, Weeton (1987)	44
2.6	Spray -up process, Weeton (1987)	46
2.7	Filament Winding process, Campbell (2003)	47
2.8	Most common forms of wood composite elements (Courtesy G.G. Marra 1979)	50
2.9	Particle board structure. (A. Jayne and Bodig 1982)	51
2.10	Fiber board structure . (A. Jayne and Bodig 1982)	52
2.11	Mixed of Sawdust	59
2.12	Mixed of Chip wood	57
2.13	Type I Chip (Ratnasingam 2002)	58
2.14	Type II Chip(Ratnasingam 2002)	59
2.15	Type III Chip(Ratnasingam 2002)	59
3.1	Research flowchart for the production and testing of composites sample	65
3.2	The CW fiber with different size categories (a) CW coarse fiber (b) CW Rough fiber and (c) CW soft fiber	68
3.3	The SW fiber with different size categories (a) SW coarse fiber	68

(b) SW Rough fiber and (c) SW soft fiber

3.4	Composite material inside the glass mould loading and various type of fiber.	73
3.5	The composite material already, pore inside the plaster of paris mould and waiting until it is cure.	74
3.6	A specimen for tensile testing Sawdust (SD) and Chip wood (CW)	75
3.7	A specimen of flexural testing Sawdust (SD) and Chip wood (CW)	76
3.8	The Instron Machine for Tensile testing	78
3.9	The Instron Machine for Flexural testing	78
4.1	SEM micrograph of soft tensile test of Epoxy composite magnification 100x.	93
4.2	SEM micrograph of soft tensile test of Epoxy composite magnification 100x.	93
4.3	Tensile Strength	95
4.4	Tensile Elongation	96
4.5	Tensile Young Modulus	98
4.6	SEM micrograph of course tensile test of SW/Epoxy composite magnification 100x. Fibre size 0.25-0.30mm	99
4.7	SEM micrograph of rough tensile test of SW/Epoxy composite magnification 100x. Fibre size 0.12-0.15mm	99
4.8	SEM micrograph of soft tensile test of SW/Epoxy composite magnification 100x. Fibre size 0.063-0.075mm	100
4.9	SEM micrograph of course tensile test of CW/Epoxy composite magnification 100x. Fibre size 14-15 mm	100
4.10	SEM micrograph of rough tensile test of CW/Epoxy composite magnification 100x. Fibre size 9-10 mm	100
4.11	SEM micrograph of rough tensile test of CW/Epoxy composite magnification 100x. Fibre size 4-5 mm	101



4.12	Flexural Modulus of Elasticity	102
4.13	Flexural Modulus of Rapture	103
4.14	SEM micrograph of coarse flexural test CW/Epoxy composite magnification 100x. Fibre size 14-15 mm	105
4.15	SEM micrograph of rough flexural test CW/Epoxy composite magnification 100x. Fibre size 9-10 mm	105
4.16	SEM micrograph of soft flexural test CW/Epoxy composite magnification 100x. Fibre size 4-5 mm	105
4.17	SEM micrograph of coarse flexural test SW/Epoxy composite magnification 100x. Fibre size 0.25-0.30mm	106
4.18	SEM micrograph of rough flexural test SW/Epoxy composite magnification 100x. Fibre size 0.12-0.15mm	106
4.19	SEM micrograph of soft flexural test SW/Epoxy composite magnification 100x. Fibre size 0.063-0.075mm	106



## LIST OF ABBREVIATIONS

$T_g$	Glass transition temperature
WPCs'	Wood/plastic composites
PAN	Polyacrylonitrile
PET	Polyethyleneterephthalate
PTFE	Polytetrafluoroethylene
CVD	Chemical vapor deposition
UV	Ultraviolet
DGEBA	Diglycidyl ether of bisphenol A
TGNDA	Tetraglycidyl methylenedianiline
DDS	Diaminodiphenyl Sulfone
$BF_3$	Boron Trifluoride Amine Complex
PVC	Polyvinyl chloride
PE	polyethylene
FPL	Forest Products Laboratory
MC	Moisture contents
ASTM	American Society for Testing and Materials
SW	Saw Dust
CW	Chip Wood
ANOVA	Analysis of Variance
KN	Kilo Newton
GRP	Glass Fiber Reinforced Plastic
MOR	Modulus of rupture
MOE	Modulus of elasticity
SPSS	Statistical Package for Social Sciences
HSD	Honestly significant difference
LSD	Least significant difference
SD	Standard Deviation



# CHAPTER 1

## INTRODUCTION

### 1.1 Background

A composite material is one of the fastest growing industries with USA being the major consumer of composite materials. The global consumption of composite is now around two million tones annually and grow at the rate of 10 percent every year (Parasad, 1996). Studied by Susan *et. al.*, (2004) composites containing recycled plastics and wood fiber offer an interesting combination of properties, as well as lower cost than competitive materials, especially those based on synthetic fibers. Historically, most of these used wood flour to produce filled plastics. The wood flour decreased the cost, but was not usually intended to improve the performance in any substantial way.

A composite, as its name suggests, is made by combining two or dissimilar materials in such a way that the resultant material is endowed with properties superior to any of its parental ones. The ancients knew that when they made alloys of metal they often got good result (Parasad, 1996). Like some of the materials, example by melting together copper and tin they made bronze, the earliest know alloy. Bronze had qualities superior to its parent metals neither of which could be identified once the alloy was formed. Nevertheless, they remain strongly bonded together while maintaining an interface between on another and act mutually to give a much-improved performance.

The increase and importance of product development in the market, composite materials proven as the effective materials can reduce the manufacturing cost and increase of the product quality. The polymers composite are not only displacing conventional engineering materials in many of their applications but also creating latest application unique to the end user. Nowadays, composite are often the material of choice of engineering for a variety of reason, including lightweight, high stiffness, high strength, low thermal expansion, corrosion resistance, and long fatigue life. In nature the example are a coconut palm, cellulose fiber in lignin matrix (wood), collagen fibers in an apatite bone and others.

In recent years, interest in the development of new composite materials derived from wood fibre and thermoplastic polymer matrices has grown markedly .Today the use of composite materials in all kind of structure is increasing rapidly especially in aviation and all industry. Aviation composite technology has advanced to the point where it is strong enough to be applied in primary and secondary structure. New development in materials technologies have had made it possible to design and build wood composite product that can perform better and operate more efficiently. This is where the use of composite materials has directly enhance the capability of commercial and wood composite in term of weight saving, strength and maneuverability (Jozsef,1982).

Today, plastic goods are getting more and more interest suitable to their multipurpose applications. However, disadvantages of the plastic turn up when they are essential to admit high forces or be stiffer. The trendy inorganic reinforcing component, such as glass fibres is extremely expensive therefore, one possible



option to reduce the composite production cost is to use organic wood fibres because of their abundance, favourable cost and high stiffness. In wood industries such as the furniture industry or paper industry, a great amount of wood flakes and wood flours in the form of sawdust are always found as wastes. These unused materials are usually applied as a fuel source or for the manufacture of plywood. Since of high accessibility and low cost of the sawdust, it can be more flexible and significant by compounding the sawdust with plastics in order to improve plastic properties, for example, high strength and easy processing that are better than wood or plastics. In the related literature, it has been reported that most polymer composites involve fibre reinforcement, for instance, bamboo fibres (Chen *et al.*, 1998), fibres from oil palm empty fruit bunch (Rozman *et al.*, 2003), Bamboo fibre filled natural rubber composites (Hanif I. *et al.*, 2002), and Mechanical performance of woodfibre (Krishnan Jayaraman and Debes Bhattacharyya 2004). Ash from timber waste as cement replacement material (Elinwa and Mahmood (2002).

Wood known a valuable natural composite material with a very large utilization as solid wood or in wood-based composite materials. Its qualities but also its defects (dimensional instability, susceptibility to biological attack, anisotropy) are due to its complex structure.

Wood is a unique material. It stand alone in many characteristics when compare with man-made such as steel, concrete, stone, brick, and most synthetics. Its is already complex nature is further modified when used in products ranging from large glued-laminated members spanning hundreds of feet to small items such as a sheet of paper or a toy (Jozsef,1982).