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INVESTIGATION ON MECHANICAL PROPERTIES OF COIR FIBER REINFORCED POLYPROPYLENE COMPOSITES

Abdul Hakim Bin Razali

Bachelor of Engineering with Honours
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Alamat tetap:

Lot 2330, Lrg C7, Kpg Tunku, Jln Astana
93050 Petra Jaya, Kuching, Sarawak

En Noor Hisyam Noor Mohamed
Nama Penyelia

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INVESTIGATION ON MECHANICAL PROPERTIES OF COIR FIBER REINFORCED POLYPROPYLENE COMPOSITES

ABDUL HAKIM BIN RAZALI

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Dedicated to my beloved parent;

Razali bin Baki and Norlila Hassan

and all of my siblings for their continuing support and encouragement

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LIST OF ABBREVIATIONS

ABS	-	Air bag system
ASTM	-	American standard of testing material
A_t	-	Cross sectional area
b	-	Width
C	-	Carbon
CO_2	-	Carbon dioxide
$CO(NH_2)_2$	-	Urea
cm	-	Centimeter
°C	-	Degree Celsius
C_6H_7N	-	Aniline
CMCs	-	Ceramic matrix composites
CCMs	-	Carbon-carbon matrix composites
CPE	-	Chlorinated Polyethylene
d	-	Thickness
E	-	Modulus of elasticity
gm	-	Gram
GPa	-	Giga Pascal
HDPE	-	High density polyethylene
L	-	Support span
m	-	Slope

mm	-	Millimeter
MPa	-	Mega Pascal
LDPE	-	Low density polyethylene
MaPP	-	Maleated Polypropylene
MaPE	-	Maleated Polyethylene
NaOH	-	Sodium Hydroxide
$NaNO_3$	-	Sodium Nitrate
$NaIO_4$	-	Sodium Periodate
O	-	Oxygen
P	-	Maximum load
PMCs	-	Polymer matrix composites
PS	-	Polystyrene
PVC	-	Polyvinyl Chloride
SMC	-	Sheet Molding Compound
W	-	Breaking load
wt	-	Weight
σ_{UT}	-	Tensile strength
σ_{fs}	-	Flexural strength

ABSTRACT

Nowadays, research and development on the usage of natural fiber as reinforcement in polymers such as polyethylene, polyester and others have been given considerable attention. It is due to the advantages of this natural fiber that are low cost, low density, availability, acceptable specific strength, renewable resource and environmental friendly. In this research, the comparison between the mechanical properties of the raw coir fiber (untreated) and treated coir fiber reinforced with polypropylene (PP) matrix are studied. Hot compression technique has been used to manufacture coir-PP composites. The raw coir fiber were chemically treated with the mixture of sodium hydroxide (NaOH), sodium nitrate ($NaNO_3$) and aniline (C_6H_7N) in order to increase the compatibility with PP. Five level of fiber loading (10%, 15%, 20%, 25%, 30%) were used in the fabrication of raw and treated coir-PP composites to investigate the fiber loading with the best interfacial bonding that contributes to the optimum value of mechanical properties. Scanning Electron Microscopes (SEM) shows that there is better interfacial bonding between treated coir-PP composites compared to the raw coir-PP composites. Apart from that, results obtained from tensile and flexural test confirmed that there is an increase of tensile and flexural strength as fiber loading increases. However, after 20% fiber loading, the tensile and flexural strength decreased. For tensile and flexural modulus, the similar results are obtained. On the other hand, results on water absorption shows that the raw coir-PP absorbs more water that the treated coir-PP composites.

ABSTRAK

Dewasa ini, kajian dan pembangunan berkenaan dengan penggunaan serat semulajadi sebagai pengukuh kepada polimer seperti polietilena, polyester dan lain-lain semakin menjadi perhatian. Ini kerana kelebihan yang ada pada serat semulajadi itu sendiri yang lebih murah, kurang tumpat, mudah didapati, kekuatan spesifik yang boleh diterima, sumber yang boleh diperbaharui, tidak mencemarkan alam sekitar dan banyak lagi. Teknik secara tekanan pada suhu tinggi telah digunakan untuk menghasilkan komposit serat kelapa dengan polipropilena. Kajian ini menekankan tentang perbandingan sifat-sifat mekanikal komposit serat kelapa mentah dengan serat kelapa yang dirawat Serat kelapa telah dirawat dengan campuran bahan kimia natrium hidroksida (NaOH), natrium nitrat ($NaNO_3$) dan anilin (C_6H_7N) untuk meningkatkan keaktifan bertindak balas dengan polipropilena. Lima tahap peratusan (10%, 15%, 20%, 25%, 30%) kandungan serat kelapa telah digunakan untuk membuat komposit dengan tujuan untuk mencari peratusan serat yang mana dapat memberikan kekuatan ikatan yang paling tinggi yang menyumbang kepada sifat-sifat mekanikal yang paling maksimum. *Scanning electron miscroscope* menunjukkan kekuatan ikatan antara komposit serat kelapa yang dirawat lebih baik daripada komposit serat kelapa yang biasa. Selain itu, ujian *tensile* dan *flexural* membuktikan bahawa kekuatan *tensile* dan *flexural* bertambah dangan meningkatnya kandungan serat dalam komposit. Tetapi, kekuatan tersebut menurun selepas kandungan serat sebanyak 20%. Perkara yang sama terjadi kepada *tensile* dan *flexural modulus.*

Keputusan ujian serapan air pula menunjukkan komposit serat kelapa biasa menyerap lebih banyak air daripada komposit serat kelapa yang telah dirawat.

CHAPTER 1

INTRODUCTION

1.1 Background

Composite material first known application occurred many years ago when the Egyptians started using straw strengthened sun dried clay bricks in construction. Since that time the development of composite material evolves extraordinarily with increase in mechanical properties such as strength, stiffness and chemical and temperature resistance. Each year, there are approximately 3.5 billion pounds of glass fiber produced worldwide compared to the 30 million pounds of carbon fiber [1]. Modern composites were used in the 1930s where glass fibers were introduced [2]. Glass fiber commonly called as fiberglass was widely used in boat and aircraft at that time. Nowadays, the application of this composite material becomes more diverse in various industry such as manufacturing, automotive and spacecraft industry. In the United States, there are about 3 billion pounds of composites product manufactured each year and approximately 2000 material supplier and composites manufacturing plants across the U.S which employ more than 150, 000 people [1]. This proves that research and development in composite material is very useful in order to contribute in economy stabilities, give more work opportunity and wealth to people in one nation.

According to Food and Agricultural Organization, Brazil produces the largest amount of sisal while henequen is grown in Mexico. Abaca and hemp are grown in Philippines. The largest producers of jute are India, China and

Bangladesh [2]. Table 1.1 shows the fiber and its countries of origin, whereas Table 1.2 shows the annual production of natural fiber and its source. In Malaysia, agricultural industry enlarged and contributes about 16 percentage of national income [3]. Unfortunately, the wastes from this industry are not fully utilized although thousands of tons of different crop are produced every day. Coconut fiber, flax, wheat, kapok, oats, grass, cane (sugar and bamboo) coconut spathe, jute fiber, wheat husk, oil palm fiber, rice husk and their straws, sisal, wood fiber, banana fiber, pineapple leaf fiber, papyrus, kenaf fiber and shells of various dry fruit are included in agricultural wastes [4]. All these agricultural wastes can be utilized to produce or prepare the natural fiber reinforced polymer composites for commercial purposes. Thus, natural fiber reinforced composites is relevant topic to discuss since it involves recycle of wastes that can be used for variety of purposes. For over 3, 000 years, natural fibers have been used to reinforce material. Research that had been conducted showed that in many applications, natural fiber can replace glass fiber as that application does not require very high load bearing capabilities [5]. Latest technology in automotive application, non-wood fiber such as hemp, kenaf, flax and sisal has attained commercial success in the design of bio composites from polypropylene. In Brazilians truck, the trim part is made of a mixture of jute coffee bag wastes and polypropylene bags [6].

Table 1.1 Fibers and countries of origin [2].

Fibers	Countries of Origin
Abaca	Malaysia, Uganda, Philippines, Bolivia
Coir	India, Sri Lanka, Malaysia, Philippines
Flax	Borneo
Jute	India, Jamaica, Ghana, Malawi, Sudan
Hemp	Yugoslavia
Kenaf	Iraq, Tanzania, Jamaica, South Africa
Roselle	Malaysia, Sri Lanka, Indonesia
Ramie	Honduras, Mauritius
Sisal	East Africa, Bahamas, Kenya, India
Sun Hemp	Nigeria, India

Table 1.2 Annual productions of natural fibers and sources [2].

Fiber Source	World Production, 10^3 Tons
Abaca	70
Bamboo	10 000
Banana	200
Coir	100
Flax	810
Hemp	215
Jute	2 500
Kenaf	770
Oil Palm Fruits	Abundant
Ramie	100
Roselle	250
Rice Husks	Abundant
Sisal	380

The coconut is small holder crop that is grown on 11.6 million hectares in 86 countries. It can be found in different types and shapes as in shown figure 1.1. Coconut is native to coastal areas (the littoral zone) of Southeast Asia (Malaysia, Indonesia, Philippines). "Tree of life" or "tree of heaven" is basically a term or word refer to the coconut tree as it can produce products for food, shelter and energy to farm households and various commercial and industrial products. Strategic plan and research to these potential crop could increase food production, improve nutrition generate income and create employment. In India, due to the development in geo-textiles in applications of coir fiber in world market, it has generated income for coconuts farmers. India has earned about US$ 2922 million in 1998-1999 [7].

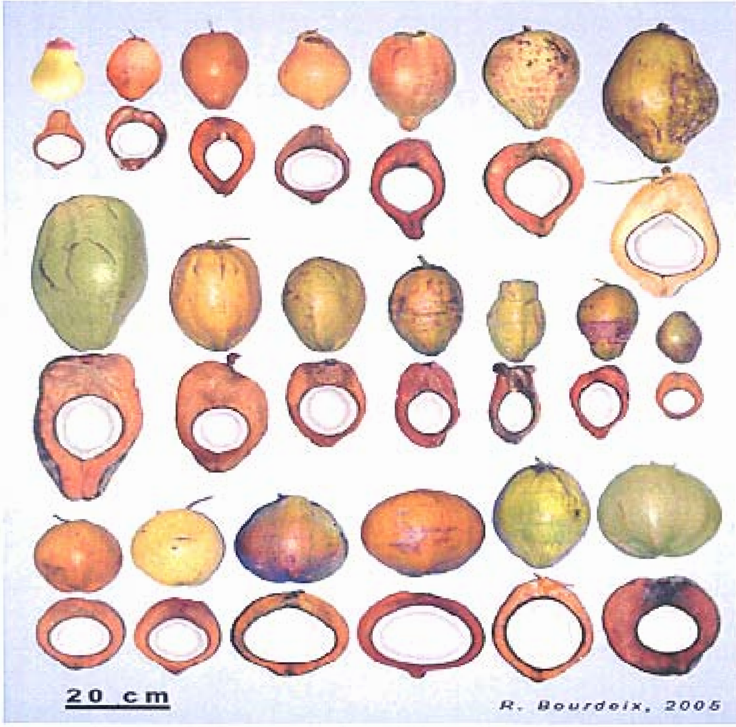

Figure 1.1 Different types and shapes of coconut [7].

This report will emphasize on coir fibers which is one of natural fiber. Grown extensively in tropical countries, coir is a versatile lingo-cellulosic fiber that is obtained from coconut tree (Cocos nuficera). Durability and other advantages make coir fiber suitable for making wide variety of floor-furnishing materials, yarn, rope etc [8, 9]. It is also a cheap fiber, even cheaper than sisal and jute [10]. Coir fibers are not as brittle as glass fibers, are amenable to chemical modification, non-toxic and possess no waste disposal problems. Unfortunately, the performance of coir as a reinforcement in polymer composites is unsatisfactory and not comparable even with other natural fibers. Low cellulose content, high lignin content, high and microfibrillar angle are several factors that contribute to the low-grade performance of coir. Coir fibers can