UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Study on the strength and mechanical properties of biocomposite of palm fibers sandwich matrix with ABS thermoplastic for ballistic armor

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Degree of Bachelor of Engineering (Honours) Manufacturing (Material Engineering)

By

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DECLARATION

I hereby, declared this thesis entitled "Study on the strength and mechanical properties of palm fibers sandwich matrix with ABS thermoplastic for ballistic armor" is the results of my own research except as cited in references

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ABSTRACT

To study the strength and mechanical properties of bi-composite of palm fibers sandwich matrix with ABS thermoplastic for ballistic armor. It is a product of polymer matrix composite which had attracts people because of its capability. This fiber and ABS thermoplastic mixed in the hot molding press. This process combines 2 principles which are pressure and temperature. The short fiber shows lower mechanical properties than the long fiber such as the impact strength. The short fiber is tested for 3 different fractions which are 10%, 15%, and 20%. The increasing of fiber reducing the elasticity and the composite become more brittle. The testing was done according to the standard ASTM. The impact strength of single layer is higher than the double cross and weave layer. However, it only can stand high force at single direction which is perpendicular to the fiber orientation. The microstructure of the composite can be seen through the Scanning Electron Microscope (SEM). From this microstructure, defects such as porosity, and inhomogeneous can be seen.

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ABSTRAK

Mengkaji sifat mekanikal dan kekuatan gentian tandan kelapa sawit yang disaluti dengan polimer ABS. tandan kelapa sawit telah diperolehi daripada kilang memproses minyak sawit. Manakala polimer ABS pula diperolehi daripada makmal acuan yang terletak di fakulti pembuatan. Kajian ini dimulakan dengan penyediaan gentian tandan kelapa sawit tersebut melalui proses "water retting" di mana tandan kelapa sawit tersebut direndam di dalam air untuk memutuskan ikatan lignosellulosik antara gentian tersebut. Apabila penyediaan gentian sudah selesai, gentian ini akan dipotong menggunakan mesin pengisar bagi menghasilkan gentian pendek. Manakala gentian panjang disusun mengikut 3 jenis susunan. Gentian pendek tersebut dicampur menggunakan mesin pengadun. Seterusnya, plat sampel disediakan dengan mengunakan "hot press". Terdapat 2 ketebalan yang digunakan iaitu 2mm dan 3mm sesuai dengan standard ASTM bagi komposit. Terdapat 3 komposisi gentian pendek diuji dan 3 jenis susunan bagi gentian panjang. Sifat mekanikal bagi komposit yang menggunakan gentian panjang lebih tinggi daripada komposit yang menggunakan geentian pendek. Komposit gentian pendek ini mempunyai kekuatan yang rendah dan bersifat rapuh.

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DEDICATION

For all your advice and encouragement, this thesis is gratefully dedicated to my family and my friends. Thank you very much for your continuous support and effort towards the publication of this thesis.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

EFB	-	Empty Fruit Bunch
ABS	-	Acrylonitrile Butadiene Styrene
RTM	-	Resin Transfer Moulding
SEM	-	Scanning Electron Microscope
ASTM	-	American Standard Test Method
PSM	-	Projek Sarjana Muda
PMC	-	Polymer Matrix Composite
PU	-	Polyurethane
PP	-	Polypropylene
PS	-	Polystyrene
PMMA	-	Polymethylmethacrylate
OH	-	Hydroxyl ion
°C	-	Degree of Celcius.
T	-	Temperature
ε	-	Strain
σ	-	Stress
FFB	-	Fresh Fruit Bunch
CPO	-	Crude Palm Oil
UTM	-	Universal Tensile Machine
UTS	-	Ultimate Tensile Strength

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1 CHAPTER 1

INTRODUCTION

1.1 Background

There are many palm oil mill in our country which are producing crude palm oil(CPO). This CPO is produced from the palm fruit which contains a lot of oil in the mesocarp. After the palm fruits were sterilized in the horizontal or vertical sterilizer, this fruits will be separates from its bunch. This bunch will be sent to the estate as the fertilizer (see appendix 1). However, it takes time for this empty bunch fruit to degrade.

The empty fruit bunch also has other potential besides be a fertilizer. It has the characteristic of natural fiber which is can be used in making composite product. This composite is an advance technology that attracts a lot of people's interest because of its performance and it's lightweight. In the composite, it is act as the reinforcement which is can improves the matrix properties and also to the composite product.

Armor is protective clothing intended to defend its wearer from intentional harm and injuries in combat and military engagements. Typically, it is related to soldiers and police. The first protective clothing and shields were made from animal skins. Then, advance civilizations had using wood as the armor. The stronger properties of metal then been used at the Middle Ages era. As we know the knights are using this metal body armor when fighting and combating.

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Armor has been used throughout recorded history, beginning with hides, leather, and bone, before progressing to bronze, then steel. During the Roman Era, modern fabrics such as Kevlar, Dyneema and ceramics were used. These changes of armor are due to a few factors such as strength, toughness, and weight.

Figure 1.1 : Steel breastplates

During World War II, flak jackets were worn by US Navy personnel on aircraft carriers during battle, since the ships and especially their flight decks offered little protection for their crew. The flak jacket was made of nylon fabric and capable of stopping flak and shrapnel. It has the advantage of lightweight because it is not using metal materials. However, it cannot stand on the bullet's impact.

Figure 1.2: The flak jacket

Kevlar is made of synthetic fiber which is woven into fabric and layered. It is produced by the DuPont Corporation in the mid-1970s. The lightweight characteristic is the main advantage of this type of armor which is gives comfort to it's wearer or soldier. It has tensile strength of 3.0 Gpa and relative density of 1.44. The high impact strength and lightweight make it chosen to be the protecting clothes for soldiers. Kevlar is five times stronger than the same weight of steel.

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Figure 1.3: Kevlar body armor

Kevlar does also have a few disadvantages such as the fibers themselves absorb moisture. Thus, Kevlar composites more sensitive to the environment and increase its weight. Although tensile strength and modulus are high, compressive properties are relatively poor. Kevlar is also very difficult to cut. Special scissors are required for cutting dry fabric and special drill bits for drilling cured laminates. However, it is very expensive materials.

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1.2 Research Objectives

This research has a few objectives such as:

1.2.1 To study the mechanical properties of bio-composite of palm fiber sandwich matrix with ABS.

1.2.2 To study the bonding that consists in the bio-composite of palm fiber sandwich matrix with ABS.

1.2.3 To analyze the product's application for product design of ballistic armor.

1.3 Research Methodology

1.3.1 To develop the sandwich matrix with resin materials from raw material and bio-composition of palm empty fruit bunch fiber for a plate sample.

1.3.2 To applied the fabrication process of producing bio-composite.

1.3.3 To applied the mechanical properties test for bio-composite through experiment.

1.3.4 To gain the appropriate process of producing this bio-composite.

1.4 Scope of Study

This study cover for the tensile, flexural, and impact strength of the polymer matrix composite of ABS thermoplastic and EFB fibers as the reinforcement. The composition of fibers is observed for the short fiber composite. For the long fiber composite, the effect of types of layer to the properties has been observed but the composition is constant. However, this study not covers for the others properties and the effect of thermal to the properties.

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2 CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are a lot of polymers which is categorized into two types; thermoset and thermoplastic. Composite is the types of materials that has attract interest of many people. It is the mixed and combination of two or more materials. Besides that, natural materials also been researched due to their good properties and low cost.

2.1.1 Polymer

Polymers are a large class of materials consisting of many small molecules which is called monomer, that can be linked together to form long chains. Thus, they are also called macromolecules. Polymers are a group of organic, semi organic, or inorganic. There are 3 types of polymers which are homopolymer, and copolymer. Homopolymer derived from one type of monomer and the copolymer is derived from 2 or more different monomers which has good properties results of those monomer's properties.

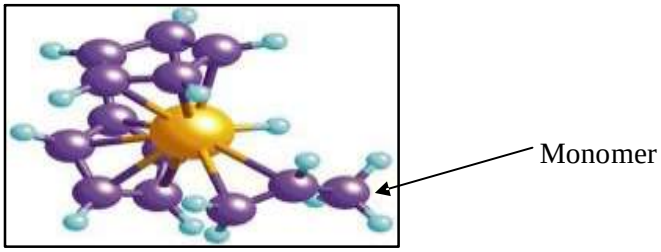

Figure 2.1: Polymer

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2.1.2 Classification of Polymer

The polymers can be separated into 3 main groups which are thermoplastic, thermoset, and elastomers. Figure below shows the classification of polymers:

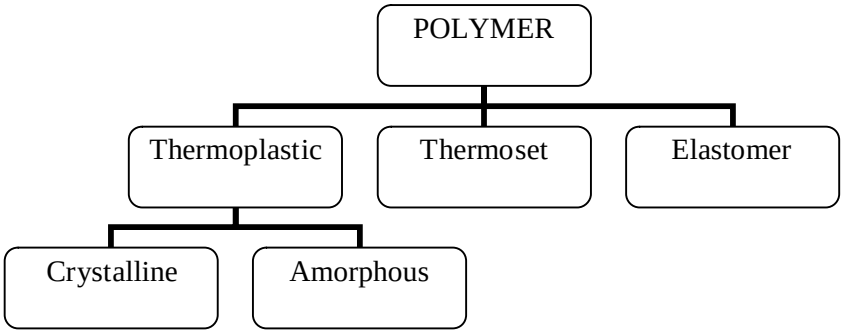

Figure 2.2: Classification of polymer

2.1.3 Polymer Structure

The polymer structure is important to be learnt. This structure results different physical and mechanical properties to the polymer. The bonding and interaction between its chains are different for different materials, thus changing its properties. Generally, there are 3 types of structures which are :

1) Linear polymers

   It has straight chain or backbone. The units or monomers are connected to each other in a chain arrangement. For example is the high density polyethylene(HDPE) which has formula of $[CH_2\text{-}CH_2]_n$.

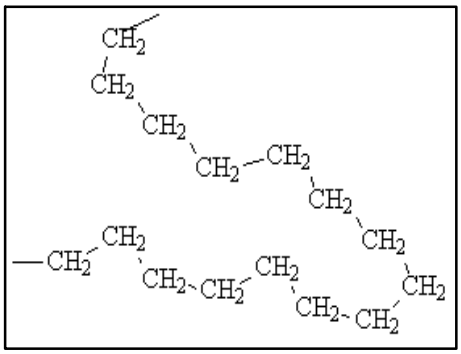

Figure 2.3: Linear polymer (HDPE)

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2) Branched polymers (non-linear)

There are branches at the backbone of the polymers. These branches have different sizes. For example is the low density polyethylene (LDPE).

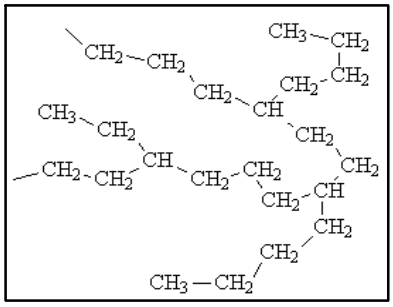

Figure 2.4: Branched polymer (LDPE)

3) Network polymers

The polymers that have cross-link between polymer chains creating three-dimensional networks. Thus, high density cross-linking restricts the motion of the chains and leads to a rigid material.

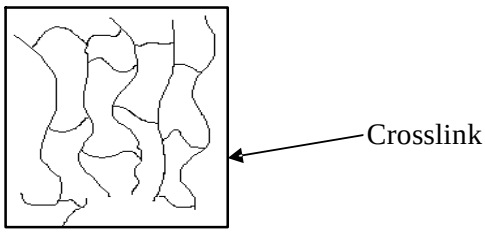

Figure 2.5: Network polymer

2.2 Thermoplastic

Thermoplastic is a material that is plastic or deformable, melts to a liquid when heated and freezes to a brittle, glassy state when cooled sufficiently. Most thermoplastics are high molecular weight polymers whose chains associate through weak van der Waals forces; stronger dipole-dipole interactions and hydrogen bonding; or even stacking of aromatic rings. Thermoplastic polymers differ from thermosetting polymers (Bakelite; vulcanized rubber) as they can be remelted and remoulded. Many thermoplastic materials are addition polymers such as vinyl chain-growth polymers such as polyethylene and polypropylene. Example of thermoplastic:

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