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TAJUK: TENSILE PROPERTIES AND MORPHOLOGY STUDIES OF POLYMERIC BIOCOMPOSITE

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DECLARATION

I hereby, declared this thesis entitled "Tensile Properties and Morphology Study of Polymeric Biocomposite" is the results of my own research except as cited in references.

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APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Material Engineering). The members of the supervisory committee are as follow:

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ABSTRACT

Polymeric bio-composite is a material formed using a polymeric matrix (resin) and a reinforcement of natural fibers which are usually derived from plants or cellulose. The objective of current research is to investigate the tensile properties of unsaturated polyester/kenaf by using the resin infusion process (RIP) in comparison with hand lay up method (HL). The effects of alkali treatment to the tensile properties of composite also were investigated. Besides, the interphase and interfacial bonding of the bio-composite especially the fracture surface of the composite will be analyzed by using SEM. The composite were fabricated by using resin infusion process and hand lay up method. The fibers were treated with different concentration and soaking time of sodium hydroxide. After that, the samples were prepared for tensile test (ASTM D638-1). According to the findings, it was observed that the optimum concentration and soaking time for composite was 6% and 12 hours. This is because in both processes (RIP and HL), the tensile strength were 90.808MPa (RIP) and 71.217MPa (HL) which was the highest compared to other concentration and soaking time. This was clarified further by the SEM where show smaller degree of fiber pulls out and rough surface fibers. Lastly, the tensile properties of RIP were better than HL no matter in treated or untreated composites because the results such as tensile strength, Young's modulus and maximum strain shown that the value was higher than HL in overall.

ABSTRAK

Bio komposit merupakan sejenis bahan yang dapat diperbentukkan dengan menggunakan matrik (resin) dan diperteguhkan dengan gentian semulajadi. Gentian-gentian ini adalah diperolehi melalui tumbuh-tumbuhan dan selulosa. Objektif bagi kajian ini adalah untuk mengkaji perbezaan bagi sifat ketegangan dalam komposit poliéster tak tepu/kenaf dengan menggunakan proses penyerapan resin dibandingkan dengan proses penyususnan secara lembap. Kesan daripada rawatan natrium hydroksida kepada sifat ketegangan komposit juga dikaji. Selain itu, interfasa dan ikatan di antara matriz dengan gentian yang wujud dalam bio komposit terutamanya pada kawasan patah juga dianalisis dengan menggunakan SEM. Bio komposit dalam kajian ini akan disediakan dengan menggunakan proses penyerapan resin dan proses penyusunan secara lembap. Gentian kenaf juga akan dirawat dengan natrium hidroksida untuk kepekatan dan masa rendaman yang berbeza sebelum diproses. Selepas itu, sampel akan disediakan untuk ujikaji ketegangan (ASTM D638-1). Dengan merujuk kepada keputusan, didapati bahawa kepekatan dan masa rendaman yang optimum adalah 6% dan 12 jam. Ini adalah kerana kekuatan tegangan untuk kedua-dua proses tersebut adalah paling tinggi iaitu mencapai lebih kurang 90.808MPa untuk proses penyerapan resin dan 72.217MPa untuk proses penyusunan secara lembap. Ini boleh dibuktikan dengan analisa SEM di mana bilangan gentian yang ditarik keluar adalah banyak dan permukaannya adalah kasar. Ini menunjukkan satu ikatan yang kuat dan teguh di antara gentian dan matrik. Akhir kata, sifat regangan untuk proses peyerapan resin adalah lebih baik daripada proses penyusunan secare lembap kerana keputusan seperti kuatan regangan, Young's modulus, dan pemanjangan maksimum menunjukkan nilai yang lebih tinggi.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

CMC		Ceramic Matrix Composite
CSM		Chopped Strand Mat
EOL	-	End of Life
ESEM	-	Environmental Scanning Electron Microscopy
FS		Flexural Strength
HL		Hand Lay Up
MAPP		Maleic Anhydride Polypropylene
MEKP		Methyl Ethyl Ketone Peroxide
MMC		Metal Matrix Composite
PP	-	Polypropylene
PE	-	Polyethylene
PMC		Polymeric Matrix Composite
RIP	-	Resin Infusion Process
ROM		Rule of Mixture
RTM		Resin Transfer Molding
SEM		Scanning Electron Microscopy
TS		Tensile Strength
UPE	-	Unsaturated Polyester

CHAPTER 1

INTRODUCTION

1.0 Background

Research in polymer composite often requires certain modifications in order to improve their properties. Additional reinforcement and filler were used to improve the mechanical and physical properties of the composite. Basically, the objective of this project is to develop a new composite with kenaf as the reinforcement in the polymer matrix which is unsaturated polyester through the resin infusion process and hand lay up method. This is because unsaturated polyester resins are extremely versatile in properties and have been a popular thermoset used as the polymer matrix in composites. Besides, they are widely produced industrially due to its advantages when compared with others thermosetting resin including transparency, good mechanical properties and room temperature cure capability. Furthermore, the reinforcement of polyesters with cellulosed fibers has been widely reported. Polyester-jute, polyester-sisal, polyester-coir polyester-banana-cotton, polyester-straw, polyester-pineapple leaf, and polyester-cotton-kapok, are some of the promising systems (Aziz et al., 2004). As for kenaf (hibiscus cannabinus), it is a member of the hibiscus family which is biodegradable and environmentally friendly crop. It has been found to be an important source of fiber for composites and other industrial applications.

The research work will focus on morphology study of the composite in relation of strength properties in the laboratory scale. As for the processing technique, it will involve several processing stage in fabricate the sample by using resin or known as vacuum infusion process and hand lay up method. Follow by this, the testing stage will be conduct in order to investigate tensile properties between these two types of process. Besides, these two types of process will also have fiber treatment by using the sodium hydroxide in order to compare its properties. Analysis of the finding will be compared between the resin infusion process and hand lay up method with different concentration of fiber treatment by using sodium hydroxide in order to verify that the new composite has the potential to be use as the substitution material in structural and automotive application.

1.1 Problem Statement

In structural area, metals are used as major application. Even though metals are known for their outstanding mechanical properties, the costs of their raw materials somehow outweigh the inherent benefits. At the same time, the selection of materials in the market has shifted to the lightweight materials. This scenario has opened an opportunity to explore the possibility of producing a lightweight composite yet at the same time maintaining the outstanding mechanical properties. The cost of manufacturing also could be reduced significantly if they are produced locally within Malaysia. In this research, the main focus is to use kenaf as the substitute materials for the steel, as reinforcement in polymer matrix in order to produce a high impact composite but lightweight. Nowadays, in Malaysia, kenaf is used mainly for furniture like its counterpart the wood and bamboo. Exploration in the bio-composite industry has unearthed its potential to be researched. The usage of metals as high impact materials in structural application is no longer viable due to the threat of over cost of the raw materials that heavily depend on natural source and mining activities. This has force the researcher to find other substitution materials and kenaf is believed has the potential to replace this role as it functions as a good reinforce in a suitable matrix material.

In addition, polymeric bio-composite is the advanced composite started to attracted attention from manufacturer especially to the automotive and structural fields. This is because of its eco-environmental friendly properties since it is bio-degradable. It is low cost, low density, high modulus strength, and so on. However, its mechanical properties are not good as normal polymeric composite which is based on the synthetic fibers such as E-glass, S-glass, aramid, and so on. Therefore, it is crucial to find out which types of composite and process is more suitable to apply in automotive and structural fields by comparing the tensile properties, microstructure, and so on.

1.2 Objectives

i. To investigate the tensile properties of polymeric bio-composite (Unsaturated Polyester/kenaf) by using resin infusion process in comparison with hand lay up method.
ii. To investigate the effects of fiber treatment to the tensile properties of polymeric bio-composites (Unsaturated Polyester /kenaf).
iii. To study the interface bonding of fiber matrix by scanning electron microscopy.

1.3 Scope

This section states the choices made during the research process and the research will conduct by follow the criteria as stated below:

i. Use of kenaf fiber extracted using decorticating machine which already available locally (the kenaf fiber is donated from Lembaga Tembakau Negeri Terengganu).
ii. The kenaf fibers are in long continuous and loose fiber forms.

iii. Use of simple and low cost fiber purification and treatment process.

iv. Use of single polymer that can be processes in the room temperature.

v. Use of single manufacturing process that involved low cost investment of tool and equipment but capable to produce high performance materials.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction to composites

Composites consist of two (or more) distinct constituents or *phases*, which when married together result in a material with entirely different properties from those of the individual components (Paul et al., 2006). In other words, composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement (Taj et al., 2007). Besides, there are 3 types of composite which are polymer matrix composite, metal matrix composite and ceramic matrix composite. However, only the polymer matrix composite will be discuss in this section since the matrix that will be used in this research is unsaturated polyester.

In fact, polymer matrix composite is the most advanced composites. Basically, polymer matrix composite can divided into two classes which are thermoplastic and thermoset. Thermoplastic refers to polymer that can be melting processed by a variety of methods, including extrusion and molding. These include polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). On the other hand, thermoset are polymer whose individual chains have been chemically linked by covalent bonds during polymerization or by subsequent chemical or thermal treatment. Once formed, the cross-linked networks resist heat softening, creep and solvent attack. Principle thermosets are epoxies, polyesters and formaldehyde-based resins. Then, thermoplastic and thermoset are reinforced by using fiber such as synthetic fibers and natural fibers.

2.1.1 Polymeric Matrix Composite (PMC)

The most common advanced composites are polymer matrix composites. These composites consist of a polymer resin as the matrix with fibers as the reinforcement medium (Callister, 2003). These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low cost, high strength and simple manufacturing principles (Taj et al., 2007).

2.1.2 Metal Matrix Composites (MMC)

The word metal matrix composite (MMC) covers a variety of materials and not only composites with continuous fiber reinforcement (John, 2003). Metal matrix composites, as the name implies, the matrix is ductile metal. These materials may be utilized at higher service temperatures than their base metal counterparts. Some of the advantages of these materials over the polymer-matrix composites include higher operating temperatures, non-flammability, and greater resistance to degradation by organic fluids. It is much more expensive than PMCs and therefore, its use is restricted (Callister, 2003). Examples of matrices in such composites include aluminum, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.