PHYSICAL AND MECHANICAL PROPERTIES OF TREATED KAPOK FIBER REINFORCED POLYESTER COMPOSITES

ZYAD SALEM ALSAGAYAR

SCHOOL OF MATERIALS ENGINEERING

UNIVERSITI MALAYSIA PERLIS

2010

PHYSICAL AND MECHANICAL PROPERTIES OF TREATED KAPOK FIBER REINFORCED POLYESTER COMPOSITES

by

ZYAD SALEM ALSAGAYAR

(0931620398)

A thesis submitted
In partial fulfillment of requirements for degree
of Master of Science (Polymer Engineering)

SCHOOL OF MATERIALS ENGINEERING

UNIVERSITI MALAYSIA PERLIS

2010

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

In the name of Allah, the Beneficent, the Merciful

With blessings and peace be upon the most honorable Prophets and Messengers, Muhammad and his Folk, Companions and those who follow noble way.

Alhamdulillah and thank to Allah, who has given me the commitment and strength to finish this research. It gives a great pleasure to write this acknowledgement. First of all, I would like to thank my supervisor, Ir. Dr. Surya who is a lecturer of School of Materials Engineering for his guidance, encouragements, suggestions, and ideas throughout the course of the work described hereby. His methodical and analytical approach toward problem solving has been very inspiring and I managed to learn something new on developing skills in the world of engineering whereas I learned in a good and healthy working environment.

Special thanks to my father Salem Mohamed, my mother Fatima, my sisters brothers and every single one of my relatives for their patience, understanding, unfailing love and support though the ups and downs. Not forgotten, I would like to express my gratitude and thanks as well to all staff and lecturers, specially Dr. Ir. Salmah Husseinsyah and laboratory technician of School of Materials Engineering for their helped, cooperation, guidance and sharing ideas in order to complete this research. An extended appreciation is also expressed to University Malaysia Perlis for giving facility and *resource in completing this study. Last but not least, I would like to thank everyone who has been involved in this project or indirectly for their help and contribution, especially all my classmates without* any *exception.* ***Thank you very much!***

THANKS TO ALMIGHTY ALLAH

ZYAD SALEM ALSAGAYAR

UNIVERSITI MALAYSIA PERLIS

UNIVERSITI MALAYSIA PERLIS

DECLARATION OF THESIS

Author's full name : **ZYAD SALEM ALSAGAYAR**..

Date of birth : **10th/02/1986**……………………………………………………….........

Title : **PHYSICAL AND MECHANICAL PROPERTIES OF TREATED KAPOK FIBER REINFORCED POLYESTER COMPOSITES**……

Academic Session : **2010-2011**………………………………………………………………...

I hereby declare that the thesis becomes the property of Universiti Malaysia Perlis (UniMAP) and to be placed at the library of UniMAP. This thesis is classified as:

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*

☐ **RESTRICTED** (Contains restricted information as specified by the organization where research was done)*

☑ **OPEN ACCESS** I agree that my thesis is to be made immediately available as hard copy or on-line open access (full text)

I, the author, give permission to the UniMAP to reproduce this thesis in whole or in part for the purpose of research or academic exchange only (except during a period of _____ years, if so requested above).

Certified by:

________________	______________________________
SIGNATURE	**SIGNATURE OF SUPERVISOR**
Y. 438354	**DR.IR.SURYADIANSYAH**
(NEW IC NO. / PASSPORT NO.)	**NAME OF SUPERVISOR**
Date: _________________	Date: _________________

NOTES: * If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentially or restriction.

SIFAT-SIFAT FIZIKAL DAN MEKANIKAL SERAT KAPOK YANG DIPERKUAT DENGAN KOMPOSIT POLIESTER

ABSTRAK

Komposit serat kapok diperolehi dengan menggunakan lima komposisi pengisi yang berbeza untuk mengkaji sifat-sifat mekanikal dan fizikal komposit tersebut. Kajian itu dibuat dengan membandingkan ciri-ciri keputusan awal dan akhir rawatan serat tersebut. Proses rawatan itu dijalankan di bawah keadaan tertentu bersama 2 % asid malik atau larutan natrium hidroksida. Kapok direndam selama dua jam di dalam larutan dan kemudian dimasukkan ke dalam oven selama 24 jam untuk dikeringkan. Serat kapok berbeza yang telah dirawat diisi dengan poliester dan kemudian ditekan dengan pemampat pada suhu 80 ^{o}C. Sampel tersebut diuji dengan kebolehan lentur,pemanjangan, impak dan penuaan hygrothermal. Pemanjangan lebih baik pada sampel yang tidak mengalami penuaan tidak kira serat tersebut dirawat dengan asid malik atau NaOh. Kekuatan lentur untuk komposit yang dirawat asid malik atau NaoH didapati berkurang dengan pertambahan beban ke atas serat. Untuk ujian ketahanan impak pula, apabila beban serat bertambah, ketahanan terhadap impak juga meningkat. Kesimpulan daripada kajian dapat dibuat ialah serat kapok perlu ditingkatkan lagi kualitinya untuk digunakan sebagai bahan penguat

PHYSICAL AND MECHANICAL PROPERTIES OF TREATED KAPOK FIBER REINFORCED POLYESTER COMPOSITES

ABSTRACT

The composite of treated kapok fibre reinforced polyester resin was carried out by using five different compositions of filler to study the physical and mechanical properties of composite. The investigation of the effect of fiber was done by comparing the characterizations results before and after the treatments of fiber. The treatment process of kapok has been done under certain conditions by 2% of maleic acid or sodium hydroxide solution, the kapok has dipped into the solution for two hours then placed in oven for 24 hours to make them dried. Different loading of treated kapok fiber was filled in polyester then moulded in compression at 80 ^{o}C. The samples were characterized under tensile, flexure, impact, and hygrothermal aging. The results showed that, better tensile properties were for unaged samples neither the kapok was treated by maleic acid or NaOH, despite they were decreased by increasing the loading of fiber. In addition, flexural strength of both composites treated by (maleic acid or NaOH) was found to be decrease as the fiber loading increased. The composites under impact strength test exhibited, as the fiber loading rise up in both cases (treated by NaOH or maleic acid) the impact strength increase stately. Due to low mechanical and physical properties exhibited by treated kapok fiber reinforced polyester it can be noted that, kapok fiber need to be improved as reinforcing material.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure No: **Page**

LIST OF SYMBOLS AND ABBREVIATION

ASTM	American Society for Testing and Materials
^{o}C	Degree Celsius
FS	Flexural Strength
g	Gram
IM	Impact Strength
KJ/m^{2}	Kilo Joule/ Meter^{2}
Kg	Kilogram
MPa	Mega Pascal
MEKP	Methyl Ethyl Ketone Peroxide
mm	Millimeter
min	Minute
%	Percentage
SEM	Scanning Electron Microscope
NaOH	Sodium Hydroxide
UPR	Unsaturated Polyester Resin
w t%	Weight Percent

CHAPTER 1

INTRODUCTION

1.1 Research Background

The use of composite materials have been used for many centuries ago, some 3000 years ago in Egypt, straw was used as a fiber to reinforce clay to build walls. In the industrial plastic, a combination plastic with wood flour or natural fiber was introduced. As one of the typical examples for application of natural fiber (cotton) embedded in polyester matrix was the body of the East German car (1950-1990). Over more, construction materials were developed more and more when the glass fiber with tough, rigid resin was able to be produced on large scale (Bledzki & Faruk., 2006).

Some properties of cotton fiber-polyester composites have been reported. These include density which was marked 1400kg/m3, tensile was at 34.5-689.6 MPa, flexural was between 62.1- 124.1 MPa while the impact resistance reached 253.3-428.8 kg m/m2, and water absorption has marked 0.8% it was for 24 hours at room temperature (Mwaikambo & Bisanda., 1999). But 25 years later it was reported that cotton fabric reinforced phenol in resin composites was used as breakings in place of phosphor bronze in the roll necks off steel and also non-ferrous rolling mills, this created in energy saving of up to 25%. Unfortunately no details regarding the fabrication and property were reported (Satyanarayana, Gregorio & Wypych., 2009).

Nowadays, a vast variety of agrarian species such as sisal, bamboo, jute, straw or pineapple leaf, are considered for use in the manufacture of plant fiber reinforced polyester composites. Even though the mechanical properties of composites have been obtained compared with neat resin, much basic research is needed before plant fiber can compete with glass fiber, and for example, a small research was done with hemp-polyester system, although hemp is generally regarded as one of the strongest and heaviest available agricultural fibers listed (Rouison, Sain & Couturier., 2006).

However wood fiber presents some benefits such as, high specific strength, low density and Young's modulus; it is non-abrasive to processing supplies, low cost and most importantly biodegradable (Karmarkar, et al., 2007). However, there are some disadvantages of wood fiber. Its hydrophilic nature is lowers the compatibility with hydrophobic polymeric matrices. It also presents dimensional stability that prevents a wider use of natural fiber composites (Barkoula, Garkhail & Peijs., 2010).The possibility of using these materials in outdoor application is to makes it necessary to analyses their mechanical behavior under the influence of ageing (Arbelaiz, et al., 2005).

Another researcher have done that, Kraft fiber was reinforced polypropylene (PP) composites to describe the influence of fiber length, fiber beating and hygrothermal ageing on tensile strength (TS), Young's modulus (YM), failure strain (FS) and impact strength (IS) and found that, TS, YM and IS of composites were found to decrease and FS increased with decreasing fiber length (Beg & Pickering., 2008). But modest levels of fiber beating increased the TS of composites, which were believed to be due to improved interfacial bonding. Then during Hygrothermal ageing, increasing the ageing temperature, the diffusion coefficient Increased. TS and YM were found to decrease for Hygrothermal ageing due to fiber damage and reduced fiber matrix interfacial bonding, whilst FS and IS were found to increase due to the plasticizing effect of water (Pegoretti & Penati., 2004). In another work, Hemp fiber was used to reinforce polyester composite and they were prepared using resin transfer molding technique and the flexural and impact behavior had been investigated. An increasing in the trend with fiber content was shown by flexural stress at break and flexural modulus. The impact strength decreased at low fiber content, but it was gradually increased with further addition of fiber (Sebe, et al., 2000).

One of natural fiber which has great relevance to Asian countries is that Jute fiber and this due to its systematic cultivation and processing, (Satyanarayana, et al., 1990). There were extensive studies about Jute fiber which have been made to fabrication jute/epoxy and jute/polyester, laminates for social uses such as low-cost housing boats. It was about studying the effect of process variables such as curing temperature and time on mechanical properties of jute fiber- polymer composites.

For the best of our knowledge, nothing has been reported on the preparation of treated kapok fiber/ polyester resin. In this project, polyester resin is used as matrix polymer whereas the kapok fiber acts as the filler, and the catalyst as the binder. Here polyester resin/kapok fiber composites are prepared and (physical and mechanical) properties such us tensile strength, flexural strength, impact strength, hygrothermal aging and SEM investigated.

1.2 Research Objectives

The primary objective of this research is to determine the physical and mechanical properties and the characterization of kapok fiber reinforced polyester resin composite of different composition. Several compositions of kapok fiber/polyester composite were prepared in order to study;

1. To study the effect of filler loading of treated kapok fiber filled polyester composites.

2. To compare between two different elements chemical treatment on natural fiber (kapok fiber) reinforced polyester composites on mechanical properties.

3. To study the effect of hygrothermal aging on tensile properties of treated kapok fiber reinforced polyester composite.

CHAPTER 2

LITEARATURE REVIEW

2.1 Composites

2.1.1 Definition of Composites

Composites are defined as materials consisting of two or more distinct phase with recognized interface or interphase. Composites can be categorize by their matrix characteristics including type (metal, ceramic, polymeric based and inorganic or organic) origin (natural or artificial) and process ability (thermoset or thermoplastic) (Karge, 1993). Another phase is called reinforcing phase, is in form of fibers, sheets, or particles and is embedded in the matrix phase.

Compared with inorganic fiber in polymeric material, filler from natural fibers exhibit a number of advantages; for example, they are low in the density and price, cause less abrasion to processing equipment, are relatively harmless, biodegradable and renewable and yet their mechanical properties are comparable to those in organic fiber (Imam, et al., 1998).

One of the min disadvantages of natural fiber/plastic composites is that, poor compatibility exhibited between the hydrophobic polymeric matrix and the hydrophilic fiber. Poor compatibility leads to the formation of a weak interface, which results on poor mechanical properties. In order to improve the wettability of the fibers onto the matrix, either a third component has to be used –the so-called compatibilizer- or the fibers have to be surface modified prior to the preparation of the composites (Fung, et al., 2003).

In recent years, composites materials have received significant attention to the scientific community and it's used in a wide variety of applications. Composite materials are chronicled from the dawn of earliest recorded history. The first known application of composite materials occurred several thousand years ago, when materials have been used for many centuries ago, as a first uses; straw was used as a fiber to reinforce clay to build walls. In the industrial plastic, a combination plastic with wood flour or natural fiber was introduced (Bledzki & Faruk. 2006).

Since that time, great strides have been done in the development of composite material. They now offer the promise of new products with extraordinary strength, stiffness, and chemical and temperature resistance. Composite materials are materials that made from two or more constituent materials with significantly different physical or chemical properties, to give a combination of properties that cannot be in the original materials (Gupta & Gupta, 2005).

The development of these new materials will enable the circumvention of classic material performance trade-off by accessing new properties and exploiting unique synergies between materials. (Chung, 2001) said that composite materials obtained by artificial combination different materials to attain properties that the individual component cannot aim.

(Tuttle, 2004) described composites materials as combination of material that is one in which two (or more) materials are bonded together to form a third material. (Strong, 2000) derived the composites material as those solid materials composed of binder or matrix that surrounding and binds together fibrous reinforcement. (Hull & Clyne, 1996) derived composites as a material that comprise of hard and discontinuous reinforcement that embedded in a weaker and continuous matrix while (Alger, 1989) has defined a composite material as a combination of two or more materials in which the individual components retain their separate identities while it exhibits different properties from those of its components. The reinforcement provides strength and rigidity, helping to support structure load. The matrix maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone.

The development of these new materials wills enables the circumvention of classic material performance trade-offs by accessing new properties and exploiting unique synergies between materials (Koo, 2006). Much naturally occurring material can be view as composites. Wood, laminated wood and bone are composite. Wood is natural composites (Tuttle, 2004). It is one of the oldest and most widely used structural materials. Wood is made up of fibrous chain of cellulose molecules in a matrix of lignin, while bone and teeth are both essentially composed of hare inorganic crystal (hydroxyapatite or osteons) in a matrix of tough organic constituent called collagen. In all composites, the filler is embedded within a matrix. The introduction of filler into the matrix alters all the properties. The filler impacts their mechanical and physical properties to enhance the matrix properties.

2.1.2 Classification of Composites

There are several different types of composites. Composites materials are often classified on the basic of the matrix material used, rather than the reinforcing material. There are three main classes, according to the natural matrix;

- ❖ Polymer matrix composites
- ❖ Metal matrix composites
- ❖ Ceramic matrix composites
- ❖ Carbon Graphic matrix composites