REINFORCEMENT OF PLASTIC USING EMPTY FRUIT BUNCH (EFB) OF PALM OIL WASTE

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DECLARATION

I declare that this thesis entitled *“Reinforcement of plastic Using Empty Fruit Bunch (EFB) of Palm Oil Waste”* is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………
Name : SHAHRUL ANUAR BIN ABD RAHMAN
Date : 27 April 2010

DEDICATION

To my beloved mother, father, families, and friends, who gave me everlasting inspiration, never ending encouragements and priceless support towards the success of this study.

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ABSTRACT

The use of natural fiber as a reinforcement in polymer composites are getting so much attention and widely used for technical application in automotive , furniture, aerospace ,packaging and others industries. demand and attraction for alternatively material from renewable resource are incredibly increased. Awareness the come out from precision analysis in many aspects for example safety, environmental impact, health and cost saving for composites production had produce one new idea in finding an alternative way to replace the limited resource material like synthetic material. The environmental issue and lower cost for natural fiber and lignocelluloses resource had attract many researcher in the entire world to make this materials as a reinforce material in composite engineering. The main resource is get from agriculture sector that produce as a waste like grain husk, pineapple leaves, kenaf, jut and coir. The objective of this research is to determine the effect of alkaline treatment on this fiber, to produce high quality fiber by treatment process and to find the effect of natural fiber reinforcement with epoxy (plastic).Method that was used in making these plastic reinforcement composites are thermosetting process where the liquefy epoxy resin will be combine with empty fruit bunch (EFB) of oil palm fiber with hot press equipment. The empty fruit bunch fiber will be treat first with alkaline treatment to remove the lignin contain and increase the surface roughness. Alkali treatment also can make fiber more hydrophobic in order to get good interfacial adhesion between fiber and thermoset polymer matrix. The resulted are 10% treatment with NaOH give the best result from effective and economic side where provide tensile strength of 14.9 MPa for 10% fiber loading where it can be used for structural applications.

ABSTRAK

Penggunaan serat alam sebagai penguat dalam komposit polimer mendapat begitu banyak perhatian dan banyak digunakan untuk aplikasi teknikal di otomotif, furnitur, aerospace, bungkusan dan industri lain. permintaan dan daya tarikan untuk bahan alternatif dari sumber daya terbarukan yang sangat meningkat. Kesedaran keluar dari analisis precision dalam banyak aspek keselamatan contohnya, kesan persekitaran, kesihatan dan penjimatan kos pengeluaran komposit telah menghasilkan satu idea baru dalam mencari cara alternatif untuk menggantikan bahan sumber daya terbatas seperti bahan sintetik. Isu persekitaran dan kos yang lebih rendah untuk serat alam dan sumber daya lignocelluloses telah menarik banyak penyelidik di seluruh dunia untuk membuat bahan ini sebagai bahan menguatkan teknik komposit. Sumber daya utama adalah mendapatkan dari sektor pertanian yang menghasilkan sebagai sisa seperti kulit gandum, daun nenas, Kenaf, unjuran dan pad. Tujuan dari penelitian ini adalah untuk menentukan pengaruh perlakuan alkali pada serat ini, untuk menghasilkan serat berkualiti tinggi oleh proses rawatan dan untuk mengetahui pengaruh penguat serat alami dengan epoxy (plastik). Kaedah yang digunakan dalam membuat komposit plastik thermosetting penguatan proses dimana mencairkan epoksi resin akan menggabungkan dengan tandan buah kosong (TKS) dari serat kelapa sawit dengan peralatan tekan panas. Serat tandan buah kosong akan memperlakukan pertama dengan perlakuan alkali untuk menghilangkan lignin mengandung dan meningkatkan kekasaran permukaan. perlakuan alkali juga boleh membuat lebih banyak serat hidrofob untuk mendapatkan adhesi antar muka yang baik antara serat dan matriks polimer termoset. Adalah perlakuan tersebut menghasilkan 10% dengan NaOH memberikan hasil yang terbaik dari sisi ekonomi yang berkesan dan mana memberikan kekuatan tarik 14,9 MPa selama 10 loading% serat di tempat yang boleh digunakan untuk aplikasi struktur.

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LIST OF ABBREVIATIONS & SYMBOLS

% - Percentage
wt% - Weight percent
cm - Centimeter
DP - Degree of polymerization
g - Gram
kg - Kilo Gram
kN - Kilo Newton
m - Meter
ml - Milliliter
mm - Millimeter
N - Normality
NaOH - Sodium Hydroxide
OH - Hydroxide
ºC - Degree Celsius
Pa - Pascal
TAPPI - Technical Association of the Pulp and Paper Industry
V - Volume
SEM - Scanning Electron Microscopy

CHAPTER 1

1.1 INTRODUCTION

The use of natural fiber as a reinforcement in polymer composites are getting so much attention and widely used for technical application in automotive , furniture, aerospace ,packaging and others industries. Biomass resource from natural fiber is a renewable and easy to get in a lower price compare to synthetic fiber. It has potential to replace the higher cost synthetic fiber like glass fiber, boron, Kevlar and others (bledzki & Gasan , 1999). Lignocelluloses fibers are used as alternative to glass fiber as a reinforcement material in composites has attractive many researchers in this field. That is because the natural fiber offer several of advantages compare to glass fiber from lower cost, ‘high performance/weight’, lighter, easy to process, reactive surface to chemical reaction other than been burn if it is not used anymore.(HPS Abdul khalil et,. 2001). One of lignocelluloses material that is very important with Malaysia scenario is waste from palm oil production industries because Malaysia produces more than 17 million tons of EFB annually. One of the major waste from this industries are empty fruit bunch (EFB).EFB are produced as a side product after the seed is pulled out from it bunch for oil extraction process (Thomas et. Al,. 1997). All the components from palm oil have several potential in many fields for example like plastic-palm oil component (Rozman et al,. 2001), rubber-palm oil components (Ismail et. Al,. 2000). pulp and paper. With advantages those natural fibers have, composites industries from thermoset and thermoplastic are fast develop and increasing.

1.2 Problem Statement

1.2.1 Demand for alternatively material

Lately, the demand and attraction for alternatively material from renewable resource are incredibly increased. Awareness the come out from precision analysis in many aspects for example safety, environmental impact, health and cost saving for composites production had produce one new idea in finding an alternative way to replace the limited resource material like synthetic material (Torres & Cubillas, 2005).Environmental problem such as global warming, energy consumed and desire to produce products from natural resources embody an interest and demand for plant based products (Reddy & Yang, 2005). From research that had been done, we know that plant is very interesting subject when we analyze as a material for composites aspects because products from this resource will give the better and various characteristic that we need.

1.2.2 Environmental issue

Influence from the consumed of synthetic fiber that give many problem such as bad impact to the environment also contribute to this revolution. Even though this synthetic fiber had give many benefit to consumer, this composites also give effect to the environment through their production process .For example, the production of glass fiber are strong depend on fossil fuel where the burning process will let free a large amount of CO2 to the atmosphere . Green house effect is a phenomenon that happen as a result from CO2 release that produce from fuel burning (eg ; petroleum). This situation is clearly different with natural co2 for lignocelluloses fiber where it more interesting and give benefit to the environment (Paul et al., 2003).

The environmental issue and lower cost for natural fiber and lignocelluloses resource had attract many researcher in the entire world to make this materials as a reinforce material in composite engineering. The main resource is get from agriculture sector that produce as a waste like grain husk, pineapple leaves, kenaf, jut and coir.

1.3 Research Objectives

1. To determine the effect of alkaline treatment on this fiber.

2. To produce high quality fiber by treatment process.

3. To find the effect of natural fiber reinforcement with epoxy (plastic).

1.4 Scopes of Study

1. To apply the thermosetting process in plastic composite production like those we know, plastic manufacturing process fall into duple that is thermoplastic and thermosetting. Both of the processes have different method and their own type resin. So in my research I want to discover the thermosetting process.

2. To discover how to make good quality fiber by alkaline treatment process. From previous research, alkaline treatments have proved that it can bring good effect to the fiber propertie

1.5 Rationale and Significance.

Trough my research I hope it will be give a new information to the community and also giving benefit to IKS (medium and small industries) that want to find new alternative raw material that is cheaper and easy to get in Malaysia especially in polymer industries. It also will give new added value to industrial agriculture industries wastes especially palm oil waste.

1.6 Research background

1. As we know there are two type of process in making the composites which are thermosetting and thermoplastic .Every process have their own method and machine to produce the composites. Both processes also use different polymer for example thermosetting use epoxy as matrix that are in the liquid form but thermoplastic are using polyethylene that are in solid form. So in my research I will apply thermosetting process for composites.

2.Alkaline treatment have been applied in many treatment process for fiber.The different between my research and the previous research are combination of fiber treatment NaOH with 5%, 10% and 15% concentration and bleaching process with H_2O_2.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Composite Material

A dictionary defines a composite as something made up of distinct parts or constituent. At the atomic level material such as some metal alloys and polymeric materials could be called composite materials since they consist of different and distinct atomic groupings. A composite material is a materials system composed of a mixture or combination of two or more micro or macro constituents that differ in form and chemical composition and are essentially insoluble in each other (bledzki & Gasan , 1999). Newer materials and composites that have both environmental and economic benefits are being developed for applications in the automotive, building, furniture and packing industries. Agro and forest resources have always played an important role in the plastic industry. A composite is a structural material which consists of combining two or more constituents or material that is different from common heterogeneous material. A composite is considered to be any multiphase material that exhibits a significant proportion of the properties of both constituent phases such that better combination of properties is realized. The constituents are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. Composites may be selected to give unusual combination of stiffness, strength, weight, high temperature performance, corrosion resistance hardness, conductivity or cost effectiveness. The combination of the polymers is classified as Figure 2.1. Composites can be classified into roughly three or four types according to the filler types:

- Particulate
- Short fiber
- long fiber
- laminate

Short and long fiber composites are composites in which the filler material has a length to diameter ratio, l/d, greater than one. Short fibre composites are generally taken to have l/d of ~100 while long fiber type would have l/d ~ ∞. Fiber glass filler for boat panel is an example of short fiber composite. Carbon fiber, aramid fiber (Kevlar®) fibers are some of the filler material used in the long fiber type composites.

Laminate is the type of composite that uses the filler material in form of sheet instead of round particles or fibers. Formica countertop is a good example of this type of composite. The matrix material is usually phenolic type thermoset polymer. The filler could be any material from craft paper (Formica) to canvas (canvas phenolic) to glass (glass filled phenolic).

Since the composites are non-homogeneous, the resulting properties will be the combination of the properties of the constituent materials. The different type of loading may call on different component of the composite to take the load. This implied that the material properties of composite materials may be different in tension and in compression as well as in bending.

2.2 Natural Fibers

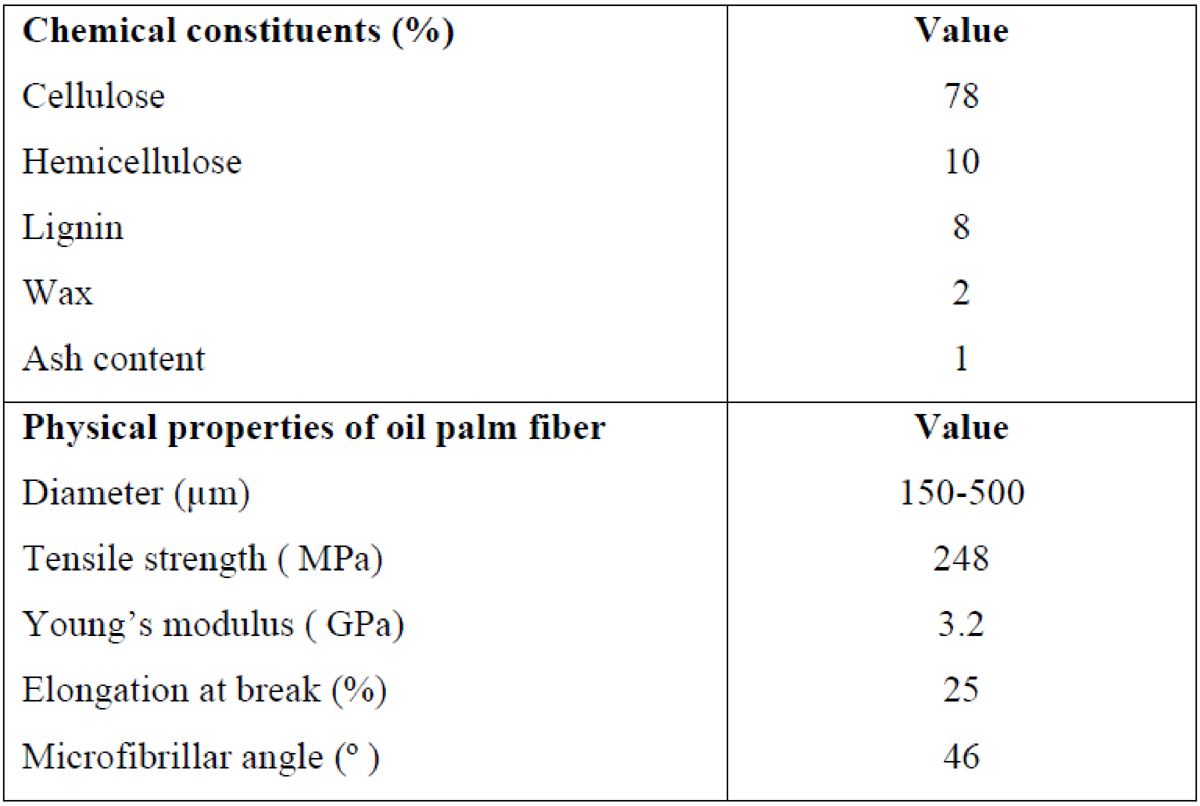
In recent years, the use of natural fibers as reinforcement is increasingly replacing the conventional inorganic fibres in polymer matrix composites. Natural fibers have recently attracted the attention of scientists and technologists because of the advantages that these provide over conventional reinforcement materials, namely, low cost, low density and high specific properties and bio-degradable characteristic. But high level of moisture absorption, poor wettability and insufficient adhesion between untreated natural fibres and the polymer matrix leads to debonding with age. Conventional fibers, like glass and carbon fibers can be produced with a definite range of properties, whereas the properties of natural fibers vary considerably depending on the fiber diameter, structure (e.g. proportion of crystalline fibrils and non crystalline region, spiral angle), supramolecular structure (degree of crystallinity), degree of polymerization, crystal structure (type of cellulose, defects, orientation of the chains of non crystalline cellulose and crystalline fibrils), void structure (pore volume, specific interface, size of pores) and finally whether the fibers are taken from the plant stem, leaf or seed and on growing conditions. To improve the properties of the composites, the natural reinforcing fibres can be modified by physical and chemical methods. Natural fibers that have been evaluated as replacements for glass and other non recyclable fibers include flax, hemp, kenaf and sisal. These natural fibers can be split into two categories bast and leaf. The bast fiber composites include kenaf and flax, while sisal may be considered a leaf fiber. The bast exhibit a superior flexural and modulus of elasticity (MOE), but the leaf fibers show superior impact properties.

Compared to glass fibers, the bast fibers tend to show approximately the same flexural strength and a higher MOE. The main drawback in using these natural fibers is the hydrophilic nature of the natural fibers, which may lead to problems of adhesion with the hydrophilic polymer matrix. High temperatures must also be avoided due to the possibility of fiber degradation. In addition, since they are grown naturally, the properties of the fibers can vary immensely from plant to plant (HPS Abdul khalil et,. 2001).

2.2.1 Oil Palm

One of the materials of this category that is of great relevance to the world and Malaysia in particular is the large quantity of biomass generated by palm industries. Oil Palm or Elais guineensis was first introduced into Malaysia in 1870. Like the coconut palm, the oil palm is grown mainly for its oil producing fruit. Owing to its commercial importance, the botanical and cultivation aspects of the oil palm have been extensively studied. Its two main products are palm oil and palm kernel oil. Traditionally, these products are used mainly in the manufacture of compound fat and soap, but now their usage has widened and varied considerably. Recently, much attention has been channeled toward finding suitable applications for oil palm industry by products. In the light of the scarcity of timber and different environmental issues, various types of by products have been studied to see whether they can serve as replacements for timber or alleviate environmental problems. At the palm oil mills the byproducts consists of shell, empty fruit bunch (EFB), presses fruit fibers (mesocarp fibers) and palm oil mill effluent (POME) .The chemical constituents and physical properties of the fibers are given in table 1.0 (Rozman et al ,2001).

Table 1.0: Properties of oil palm flour



Chemical constituents (%)	**Value**
Cellulose	78
Hemicellulose	10
Lignin	8
Wax	2
Ash content	1
Physical properties of oil palm fiber	**Value**
Diameter (μm)	150-500
Tensile strength (MPa)	248
Young's modulus (GPa)	3.2
Elongation at break (%)	25
Microfibrillar angle (°)	46

2.3 Matrix

The functions of a matrix, the binder material, whether organic, ceramic or metallic, are to support and protect the fillers, the principal load carrying agent, and to provide a means of distributing the load among and transmitting it between the fillers without itself fracturing. When filler breaks, the load from one side of the broken filler is first transferred to the matrix and subsequently to the other side of the broken filler. Typically, the matrix has a considerably lower density, stiffness (modulus), and strength than those of the reinforcing filler material, but the combination of the two main constituents (matrix and filler) produces high strength and stiffness, while still possessing a relatively low density. The matrix used in composites is classified as under:

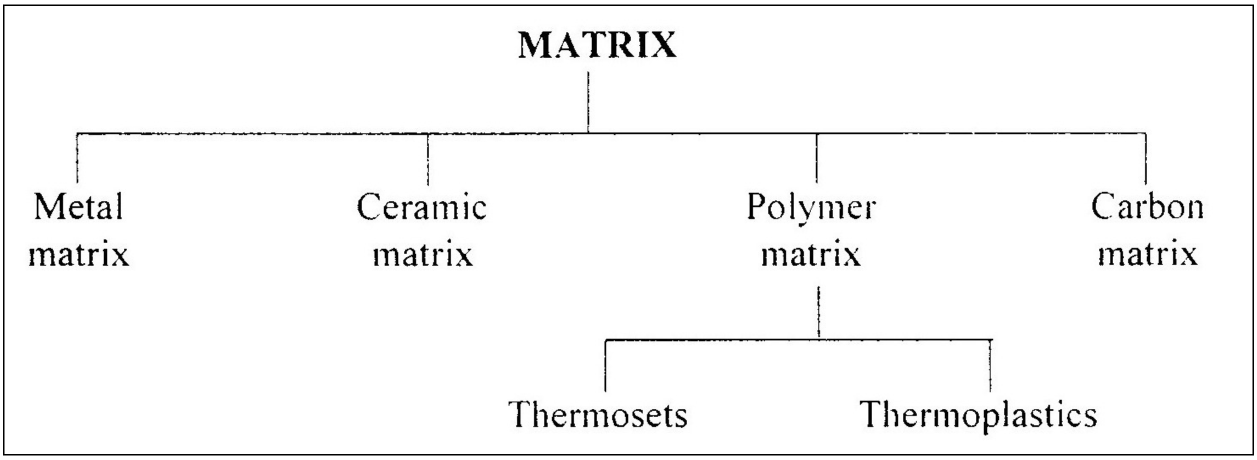


Figure 2.3: Classification of matrix

Polymer matrix composite (PMC) is a composite material for which the matrix is a polymer resin, and having fibers (normally glass, carbon, or aramid) as the dispersed phase. Ceramic matrix composite (CMC) is a composite for both matrix and dispersed phases are ceramic materials. The dispersed phase is normally added to improve fracture toughness. Metal matrix composite (MMC) is a composite material that has a metal or metal alloy as the matrix phase. The dispersed phase may be particulates, fibers, or whiskers that normally are stiffer, stronger, and/or harder than the matrix . The composites performance is influenced by the following matrix properties:

- Elastic Constants
- Yield and ultimate strength under tension, compression or shear
- Failure strain of ductility
- Fracture toughness
- Resistance to chemicals and moisture
- Thermal and oxidative stability

When selecting a particular matrix for specific composite, application, service environment parameters such as temperature stress, moisture, chemical effects and possibly radiation damage must be considered. The possibility and the processing history of the matrix must be taken into account.

2.4 Fiber Matrix Composites

Of all composite material, the fiber type specifically the inclusion of fibers in a matrix has evoked the most interest among engineers concerned with structural applications. Initially most work was done with strong, stiff fibers of solid, circular cross section in a much weaker, more flexible matrix, i.e., glass fibers in synthetic resins. Then development work disclosed the special advantages offered by metal and ceramic fibers, hollow fibers, fibers of noncircular cross section and stronger, stiffer and more heat resistant matrices.

2.5 Fillers

Fillers are used in polymer for a variety of the reasons such as cost reduction, improved processing, density control, optical effects, thermal conductivity, and control of thermal expansion, electrical properties, magnetic properties, flame retardancy and improved mechanical properties such as hardness and tear resistance. Each filler type has different properties and these in turn are influenced by the particle size, shape and surface chemistry. Filler characteristics are discussed from costs to particle morphology. Particle specific surface area and packing are important aspects. Practical aspects of filler grading are described. For example, the use of and average particle size on data sheets can be misleading as it may not accurately reflect particle size distribution. Different measuring conditions can also give rise to variations in apparent particle size. The principal filler types are outlined. These include carbon black, natural mineral fillers and synthetic mineral fillers (Rozman et al ,2001).Filler surface modification is an important topic. Most particulate fillers are inorganic and polar, which can give rise to poor compatibility with hydrocarbon polymers and processing problems, among other effects. The main types of the modifying agent and their uses are described, from fatty acids to functionalized polymers. Fillers are also discussed in relation to different polymer types. For example, in flexible PVC because of the plasticizer, the filler has little effect on processing. This allows relatively high filler levels to be incorporated. Modification of the interphase region between filler and matrix means that the interphase transfers the applied load from the matrix to the filler. In highly filled composites the interphase determines the properties of the composite. There is also a reduction in the adsorption/deactivation of the key face additives such as antioxidants and durative. There are three types of interactions when considering filler surface treatments. Firstly, interaction between the surface modifier molecule and the filler surface must usually be strong for all types of surface modifier. In most cases this is a chemical bond, which is a carboxylate linkage with a fatty acid, or strong hydrogen bond. There is also interaction between the adsorbed and non-adsorbed surface modifier and the polymer matrix. If this interaction is weak through dispersion forces, but the filler surface polarity is modified so that it matches that of the polymer matrix, then there is a noninteracting, dispersant type treatment. If this interaction is strong then a coupling agent is defined. The third type of interaction is a mutual one between the absorbed and non absorbed surface modifier molecules. If the second and third types of interaction are strong, then the treatment system is a reactive coupling or interacting one. There are two main methods of surface treatment addition. The filler may be pretreated where the surface treatment is pre-adsorbed onto the filler surface before incorporation into the matrix. However, some types of surface treatment are best added directly to the pre-mix of filler and matrix, prior to melt blending. This is known as in-situ treatment. The surface treatment then diffuses to the filler surface through the polymer matrix melt. Fillers are divided into 73 groups and their properties are analyzed. These groups include a full variety of products used by today’s industry to change optical properties and color, improve surface characteristics and dimensional stability, change thermal, magnetic and electrical properties, improve mechanical properties, durability, and rheology, affect chemical reactivity, biodegradability and performance of other additives (HPS Abdul khalil et,. 2001).

2.6 Thermosetting Plastic

Thermoset formed into a permanent shape and cured or “set” by chemical reaction cannot be remelted and reformed into another shape but degrade or decompose upon being heated too high a temperature. Thus, thermosets cannot be recycled. The term Thermosetting implies that heat is required to permanently set the plastic. There are, however, many so called thermosets that set or cure at room temperature by a chemical reaction only. Most thermosets consist of a network of carbon atoms covalently bonded to form a rigid solid. Sometimes nitrogen, oxygen, sulfur, or other atoms are also covalently bonded into a thermoset network structure (HPS Abdul khalil et,. 2001)].

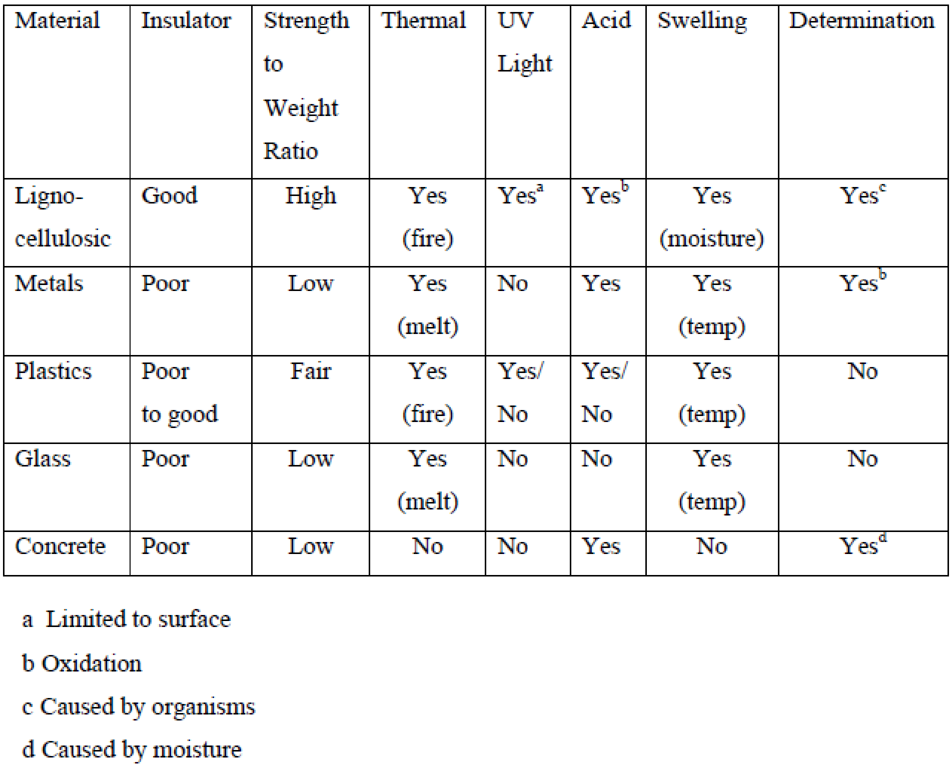
2.7 Natural Fiber Filled Polymer Composite

Natural fiber filled polymer composites is material that have natural fiber as the matrix in the composites. Natural fibers were added into the composite to reinforcing the composites. An example of natural fiber is bamboo, wood, kenaf, cotton, coconut husk,oil palm, jute, areca fruit and many more. Fibers or fibers are a class of hair-like materials that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope. They can be used as a component of composite materials. They can also be matted into sheets to make products such as paper or felt. Fibers are of two types that is natural fiber and manmade or synthetic fiber. Natural fibers include those made from plant, animal and mineral sources. Natural fibers can be classified according to their origin. Vegetables fibers are generally comprised mainly of cellulose for examples include cotton, linen, jute, flax, ramie, sisal, and hemp. Cellulose fibers serve in the manufacture of paper and cloth. Animal fibers generally comprise proteins; examples include silk, wool, angora, mohair and alpaca. Mineral fibers are naturally occurring fiber or slightly modified fiber procured from minerals. These can be categorized such as asbestos is the only naturally occurring mineral fiber. Varietions are serpentine (chrysotile) and amphiboles (amosite, crocidolite, tremolite, actinolite, and anthopillte). Ceramic fibers such as glass fibers (glass wool and quartz), aluminum oxide, silicon carbide, and boron carbide and metal fibers such as aluminum fibers (HPS Abdul khalil et,. 2001).

2.8 Lignocellulosic

Lignocellulosic materials, which predominantly consist of cellulose, lignin and hemicellulose, in the production of the plastic composites has gained momentum in recent years. Lignocellulosic materials, especially wood, have stimulated much interesting the manufacture of composites during the past decade, i.e., used as filler material instead of conventional filler such as mica, clay and glass fibers. In recent years, the search for appropriate utilization of lignocellulosic materials (other than wood) has been growing, either for replacing existing wood species in making conventional panel products or for producing plastic composites. The increasing trend in using these nonwood materials has been induced by growing demand for lightweight, high performance materials in an age of diminishing natural fiber resources (wood in particular) and escalating raw materials and energy. Thus, the prospect of using oil palm by products in various products is increasingly bright in the light of the demand for lignocellulosic materials in vast areas of applications. In general, the utilization of lignocellulosic material in the production of plastic composites is becoming more attractive, particularly for low cost/ high volume applications. There are several factors responsible for the observed trend. Lignocellulosic derived fillers possess several advantages compared to inorganic fillers, i.e., lower density, greater deformability, less abrasiveness to equipment, and lower cost. More importantly, lignocellulosic based fillers are derived from a renewable resource, available in relative abundance, of which the potential has not been really tapped. Lignocellulosic materials including wood and oil palm by products such as empty fruit bunch (EFB) have significantly lower density than the common inorganic fillers. Thus, specific mechanical properties (strength to weight ratio) of these lignocellulosic plastic composites, in addition to those characteristics mentioned before, often exceed those of other filled plastic owing to this favorable density difference. Lignocellulosic- polypropylene composites have complex morphologies that influence their behavior (HPS Abdul khalil et,. 2001).

Table 2.8: The properties of several commonly used in engineering materials



Material	Insulator	Strength to Weight Ratio	Thermal	UV Light	Acid	Swelling	Determination
Ligno-cellulosic	Good	High	Yes (fire)	Yes[a]	Yes[b]	Yes (moisture)	Yes[c]
Metals	Poor	Low	Yes (melt)	No	Yes	Yes (temp)	Yes[b]
Plastics	Poor to good	Fair	Yes (fire)	Yes/ No	Yes/ No	Yes (temp)	No
Glass	Poor	Low	Yes (melt)	No	No	Yes (temp)	No
Concrete	Poor	Low	No	No	Yes	No	Yes[d]

a Limited to surface
b Oxidation
c Caused by organisms
d Caused by moisture

Wood and other lignocellulosics swell as a result of moisture but metals, plastics and glass also swell as a result of increases in temperature. Lignocellulosic are not the only substances that decay. Metal oxidize and concrete deteriorates as a result of moisture, pH changes and microbial action. Lignocellulosic and plastic burn but metal and glass melt and flow at high temperatures. Lignocellulosic are excellent insulating substances, the insulating capacity of other materials ranges from poor to good. Furthermore, the strength to weight ratio is very high for lignocellulosic fibers when compared to that for almost every other fiber. Given these properties, lignocellulosics compare favorably to other products (HPS Abdul khalil et,. 2001).

2.9 Advantages of Natural Fiber Filled Polymer Composite

The primary advantage claimed for these composite products are low maintenance, uniformity in properties and performance and longevity (HPS Abdul khalil et,. 2001). The advantage of the natural fiber filled polymer composite is corrosion resistance, fatigue resistance, electrical Isolation.

2.10 Disadvantages of Natural Fiber Filled Polymer Composite

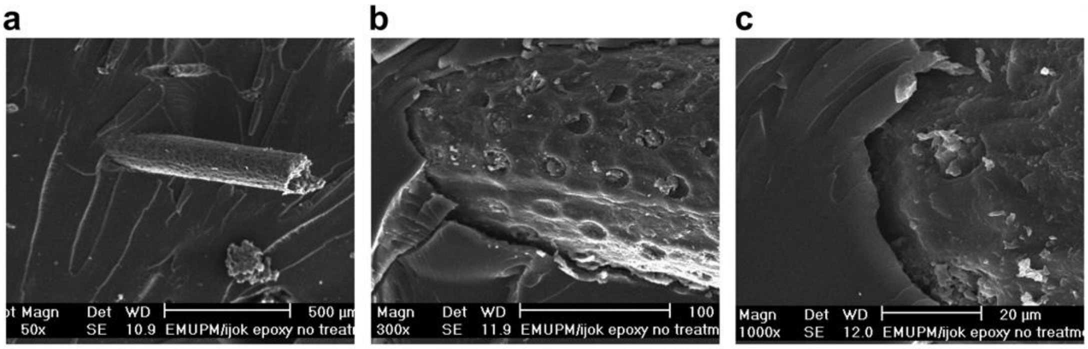
The disadvantages of the natural fiber filled polymer composite are their relatively low structural properties compared to those of structural lumber, which have limited their use to nonstructural or semi-structural application such as landscaping, piers and docks, wall panels and outdoor furniture (HPS Abdul khalil et,. 2001).

2.11 Application of Natural Fiber Filled Polymer Composite

The application of the natural fiber filled polymer composite is suitable for to made aero plane wings, space application, sporting equipment, ship building, energy technologies such as wind turbine rotor blade, wind tunnel fan, filament winding, fabric winding on mandrel, pultrusion (Rozman et al,. 2001).

2.12 Alkaline treatment

The alkaline treatment has significantly improved the tensile properties of sugar palm fibre reinforced epoxy composites particularly for tensile modulus. The hydrophilic nature of sugar palm fibre has been reduced due to this treatment and therefore has increased the interfacial bonding between matrix and fibres. However, at higher soaking times and alkaline concentrations, the effect of these parameters on tensile strength is not so pronounced because at these conditions, fibre damages may have been dominant (D. Bachtiar et al. 2008).



50x magnification **300x magnification** **1000x magnification**

Figure 2.12: SEM micrographs for untreated sugar palm fibre reinforced epoxy composite fracture after tensile loading

SEM micrographs for the composites after alkali treatment are shown in Figs. 8 and 9 for 300· magnifications. Fig. 8a shows the SEM micrograph for treated 0.25 M NaOH sugar palm fibre reinforced epoxy composite fracture after tensile loading for 1 h soaking time. The average of tensile strength is 49.875 MPa, which there is the increase of 16.4% from untreated fibre composite. The figure shows a significantly good bonding between fibre and matrix. The surface of fibre is seen rougher than untreated fibre composite sample and it may be attributed to the enhancement of the bonding strength between fibre and matrix (D. Bachtiar et al. 2008).

2.13 Epoxy resin

Epoxy resins (ER) are one of the most important classes of thermosetting polymers which are widely used as matrices for fiber-reinforced composite materials and as structural adhesives (Rozman et al ,2001).They are amorphous, highly cross-linked polymers and this structure results in these materials possessing various desirable properties such as high tensile strength and modulus, uncomplicated processing, good thermal and chemical resistance, and dimensional stability. However, it also leads to low toughness and poor crack resistance, which should be upgraded before they can be considered for many end-use applications. One of the most successful methods of improving the toughness of epoxy resin is to incorporate a second phase of dispersed rubbery particles into the cross-linked polymer . Because the addition of rubbery materials to epoxy resins has been shown to lower their glass transition temperature (Tg) and thermal and oxidative stability, high performance thermoplastics have been employed to toughen epoxy resins in recent years.

Using natural fillers to reinforce the composite materials offers the following benefits in comparison with mineral fillers:

- Strong and rigid
- Light weight
- Environmental friendly
- Economical
- Renewable and abundant resource

On the other hand, the disadvantages of the materials are summarized below:

- Degradation by moisture
- Poor surface adhesion to hydrophobic polymers
- Non-uniform filler sizes
- Not suitable for high temperature application
- Susceptibility to fungal and insect attack

Various works on the application of natural fillers and fibers in composites like pineapple, sisal, coconut coir, jute, palm, cotton, rice husk, bamboo, and wood as the reinforcements in composites have been reported in the literature. Luo and Netravali studied the tensile and flexural properties of the green composites with different pineapple fiber content and compared with the virgin resin. Sisal fiber is fairly coarse and inflexible. It has good strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in seawater. Sisal ropes and twines are widely used for marine, agricultural, shipping, and general industrial use. (Belmeres et al.., 2005). Found that sisal, henequen, and palm fiber have very similar physical, chemical, and tensile properties. Carried out a systematic study on the properties of henequen fiber and pointed out that these fibers have mechanical properties that are suitable for reinforcing thermoplastic resins (Ahmed et al).Carried out research work on filament wound cotton fiber reinforced for reinforcing high density polyethylene (HDPE) resin. (Khalid et al).Also studied the use of cotton fiber reinforced epoxy composites along with glass fiber reinforced polymers. (Fuad et al.). Investigated the new type wood-based filler derived from oil palm wood flour (OPWF) for bio-based thermoplastics composites by thermo gravimetric analysis and the results are very promising. Developed composites using jute and kenaf fiber and polypropylene resins and they reported that jute fiber provides better mechanical properties than kenaf fiber.

Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, and Sri Lanka. Many works have been devoted to use of other natural fillers in composites in the recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties. Composites of high strength coconut filler can be used in the broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances. The objective of this paper is to study the tensile and flexural properties of epoxy composites based on coconut shell filler particles.

2.14 Mechanical Properties of Various Thermoplastic Composites Filled with EFB.

Development of EFB by using several thermoplastic such as polystyrene (PS), polyvinylchloride (PVC) and high density polyethylene (HDPE). All types of composites displayed a decreasing trend in Modulus of rupture (MOR) as the filler loading was increased. As mentioned earlier, the incorporation of the fillers may disrupt the continuity of the polymer matrix which may result in the creation of more stress concentration points. Tensile strength result showed that the strength of the EFB composites with different thermoplastic matrix depended on the type of matrix used. EFB composites with PVC matrix displayed the highest tensile strength and were followed by HDPE and PS, respectively. The impact strength for various composites showed a decreasing trend as the filler loading was increased. The impact strength of EFB-HDPE composite was significantly higher than the others. This may be attributed to the ability of the HDPE matrix undergo plastic deformation in the form of crazing and shear yielding during the crack propagation process (Rozman et al ,2001).

2.14.1 Thermal Analysis

Thermal analysis is an important analytical method in understanding the structure property relationship and mastering the technology for molecular design and industrial production of different polymeric materials, especially fibre reinforced composites. Thermal analysis technique employed to obtain information about the structural transformation in polymer. Such transformations include glass transitions, melting and crystallization processes. Moreover, it is a useful technique to determine the thermal stability of the materials. In addition, it is possible to quantify the amount of moisture and volatiles present which can cause deterioration in the composites. Most of the natural fibres lose their strength at about 160 ºC. Thermal analysis studies of cellulose fibres have been carried out and the effects of crystallinity, orientation and

cross linking on the pyrolytic behaviour have been reported. One of the accepted methods for studying the thermal properties of polymeric materials is thermogravimetry analysis (TGA). TGA data indicate number of stage of thermal breakdown, weight loss of the material in each stage, threshold temperature, etc. Both TGA and derivative thermogravimetry (DTG) will provide information about the nature and extend of degradation of the material. In differential scanning calorimetry (DSC), the heat flow rate associated with a thermal event can be measured as a function of time and temperature allowing use to obtain quantitative information about melting and phase transitions of the composite system . The heat transfer modeling will require thermal and physical properties for the composites material. The measurement of thermal properties in mili-scale device such as the TGA has been used in previous studies to develop thermal properties for composites materials. The TGA method or residue weight method is the oldest and simplest method for determining solubility. In comparison to other method such as spectroscopy, calorimetry, refractometry and polimetry the TGA method is more straightforward in that detections require only a reliable microbalance. TGA also measures changes in the mass of a sample as a function of temperature and time. The measurement typically provides basic information regarding the thermal stability of both organic and inorganic, compounds and composites. Most often, TGA has been used for material analysis, including determination of degradation rates, moisture content and residual solvent. It is however not sufficient since the thermo analytical curves yield only summarized information about the process and cannot differentiate between partial reactions (Rozman et al ,2001).

CHAPTER 3

3.0 EXPERIMENTAL

3.1 Chemical

Hydrogen peroxide, H2O2.

Natrium hydroxide, NaOH.

Pottasium Iodide, KI.

Sulfuric Acid, H2SO4.

Sodium thiosulfate, $Na_2S_2O_3$.

Acetic Acid, CH_3COOH.

Starch indicator.

Potassium permanganate,KMnO4

3.2 Material

Thermosetting resin.

Kit Resin Epoxide Qc 8lb H26oz with hardener.

Natural Fiber

Empty Fruit Bunch of Palm Oil

3.3 Material Preparation EFB fibers

1. EFB fibers obtained from the supplier from oil palm factory from area Lepar , Pahang are clean with water followed by dried under the sun until it fully dried. The amount of dried fibers used depended on the desired percentage of EFB fibers in the composite.

2. After the EFB had dried. Processes for separate the fiber from their bunch are start. Only good quality fiber are selected and separated from its seed and the other impurities.

3. Next process are grinding process, where the selected fiber about 4 kg are grinded by machine into fine fiber for about 0.8 mm to 10 mm.

Grinded fibers are undergoing sieving process to separate the fiber from dust after the grinded process.

3.4 Fiber Treatment Process.

1. Mercerization Process

Next this fibers are undergo Treatment fiber process with NaOH solution in different concentration of 5% , 10% and 15% in water bath at 70^0C for 3 hour, and washed it with water for several time and dried in oven at 60^0C until it fully dried.

2. Bleaching process

After Mercerization process the fibers are soaked with 0.2% H_2O_2 AT 60^0C for 3 hours in shaking water bath. After that wash it with water for several time and dry in oven at 60^0C until it fully dries.

3. Neutralization Process

Fibers are soaked with Acetic acid 1% at room temperature until it neutral (PH=7) and dry in oven until it fully dried at 60^0C.

3.3 Testing Method

3.3.1 Determination of Kappa Number (KAPPA Test)

1. The 500 ml of 0.1 N potassium permanganate ($KMnO_4$), 4.0 N sulphuric acid (H_2SO_4), 1.0 N potassium iodide (KI), and 0.2 N sodium thiosulphate ($Na_2S_2O_3$) were prepared in the 500 ml conical flask.
2.100 ml of 0.2% starch indicator was prepared by pouring 1 g of starch into 100 ml deionized water.
3. The prepared starch indicator was cooled to room temperature before use.
The 0.5g of each sample was weighted.
4. Then, the 0.5g sample was put into the 500 ml beaker and adds 300 ml of deionized water into the same beaker.
The magnetic stirrer was put into the beaker that contains fiber solution and started to stir the solution.
5.50 ml of 0.1 N potassium permanganate solutions was measured and put into the 250 ml conical flask.
6.50 ml of 4.0 N sulphuric acid solutions was also measured and then mixed with 0.1 N potassium permanganate solutions.
7. The mixture solution was transferred into the beaker that contains fiber solution and the stop watch was started at the same time.
8. The conical flask was rinsed with 100 ml deionized water and was poured into the reaction beaker. The temperature of the reaction solution was measured.
9. After 10 minutes, the chemical reaction in the reaction beaker was stopped by adding of 10 ml 1.0 N potassium iodide solution.
10. Then, the free iodide was titrated with 0.2 N sodium thiosulphate solutions.

11. A few drops starch indicator is added into the reaction beaker when the color of the solution was changed to light yellow.
12. The titration process was stopped when the color of the solution in the reaction beaker becomes colorless.
13. The volume of 0.2 N sodium thiosulphate solutions used for the titration process was measured.
14. This experiment was repeated for blank solution with the same method but without using kenaf fiber.

3.3.2 Scanning Electron Microscope (SEM)

Figure 3.0: SEM micrograph (Carl zeiss evo 50)

1. SEM (scanning electron microscope) to determine the morphological structure of treated and untreated fiber.

Method:

a. Few sample of clean fiber untreated, 5% NaOH, 10% NaOH, and 15% NaOH are put in scanning tray.

b. A surface of the specimen was mounted on metal stubs by double-faced tape and coated with a thin layer of gold (Au).Tray are put into SEM scanning chamber and the detail structure can been seen by adjusted the optimum magnification of lens. Analyses are base on morphological structure.

3.3.3 Thermal gravimetric analysis (TGA)

Figure 3.1: TGA (Thermal gravimetric analysis) Q500

1. TGA (Thermal gravimetric analysis) to determine the thermal properties of treated and untreated fiber.

Method:

1. All 4 trays are calibrated first.

2. Few sample of clean fiber untreated, 5% NaOH, 10% NaOH, and 15% NaOH are put in tray.

3. Range of temperature is set between 30^0C- 600^0C and rate of heating are 10^0C/ min.

3.4 Fabrication process.

Next these fibers 5%, 10%, 15% are undergoing fabrication process by thermosetting process using Hot Press equipment in laboratory to get approximately 0.3 cm in thickness mat.

1. The EFB fibers were mix with epoxy as a resin by 5:1 by volume ratio of hardener with epoxy 2.The dimension of the square mat was approximately 20.0 cm^2.

3. The ratio between EFB and epoxy resin are 1:9 that was 10% from the overall volume.

4. The composite are cut into standard shape for tensile and strength test.

5. The composite board will undergo Tensile and Strength tests. The best composites are being determined.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 Kappa Test Result

Table 4.1:1st Trial of Kappa Test

Conc NaOH (%)	**$Na_2S_2O_3$ (ml)**	**p**	**f**	**kappa number**
0	17.5	65.8	1.035	136.206
5	23.7	53.4	1.006	107.4408
10	24.6	51.6	1.002	103.4064
15	25.7	49.4	0.994	98.2072

Table 4.2:2nd Trial of Kappa Test

Conc NaOH (%)	**$Na_2S_2O_3$ (ml)**	**p**	**f**	**kappa number**
0	15.3	70.2	1.044	146.5776
5	23.6	53.6	1.037	121.1664
10	25.1	50.6	1.035	104.742
15	26.7	47.4	1.206	111.3288

4.1.1 Discussion for Kappa test result

Several standardized tests have been developed to quantify the degree to which gum associated with cellulose has been hydrolyzed. Such tests are predicated on the relative quantity of non-hydrolyzed lignin that remains in natural association with a sample quantity of water-washed pulp. The "Kappa" Number test, defined by TAPPI Standard T-236 OS-76 determines the volumetric quantity of 0.1 Normal potassium permanganate solution consumed by 1 gram of washed pulp in 10 minutes at 25° C. The "Kappa" Number is 50% of the permanganate volume, in milliters, consumed. The percent of lignin remaining in association with the pulp is lignin %=0.147×"Kappa" Number Another such residual lignin test is the "K" Number or "Permanganate" Number test which is a specialized permutation or abbreviation of the "Kappa" Number test.

Traditionally, "Kappa" Number and "K" Number tests are performed manually in a chemical laboratory. More recently, automated instruments have been developed to perform the tests automatically: either from pulp "grab" samples from the process flow stream at the washers, for example, or from pulp samples taken "on-line" from a digester blow line. In either case, these automatic "Kappa" Number or "K" Number instruments are computer controlled electro-mechanical devices that are required to operate in hostile environments. Consequently, such "Kappa" Number or "K" Number instruments are subject to calibration drift.

The prior practice of "Kappa" Number or "K" Number instrument calibration required that a single pulp sample batch be "Kappa" Number or "K" Number tested in both the instrument and the laboratory. The laboratory result was taken as the control test, and the instrument result was adjusted to correspond to it. This calibration procedure was both slow and expensive (James J. Foster et al. 1993).

From first trial the kappa number for 15% of NaOH is 98.2072 which are the lowest kappa number compare to 10% of NaOH (103.4064) followed by 5% of NaOH (107.4408) and the untreated fiber (136.206).Second trial it has showed that kappa number for 10% of NaOH is 104.742 which are the lowest kappa number compare to 15% of NaOH (111.3288) followed by 5% of NaOH (121.1664) and the untreated fiber (146.5776).From 1st and 2nd trial we can summarized that at concentration 10% and 15% of NaOH give the lowest kappa number. According to the standard of Kappa Test, the lower the kappa numbers determine the lower content of lignin. From the result we can concluded that at concentration of 10% it is no good enough to remove all lignin content. Actually the kappa number that I get is very big compared to the standard that usually in range below 100. This experiment can be fixed make more test to get the better result. From my analysis the higher kappa number maybe due to a effect of starch indicator that must be add after the solution are turn in clearly light yellow.

4.2 Result for TGA (Thermal gravimetric analysis)

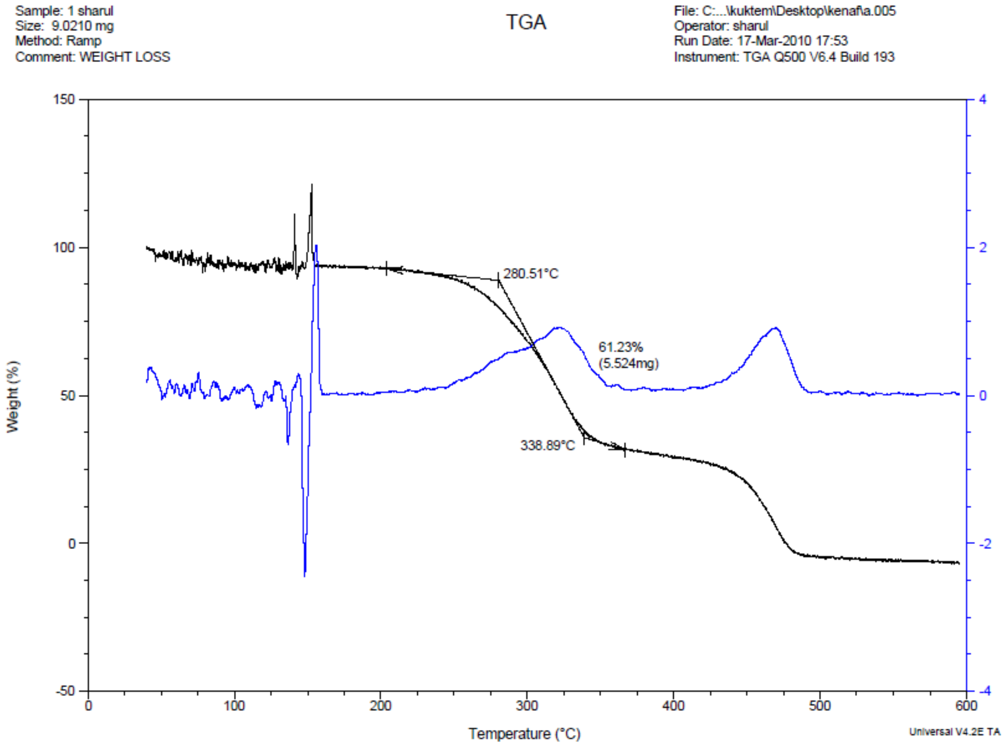


Figure 4.1: Decomposition profile of untreated EFB fiber

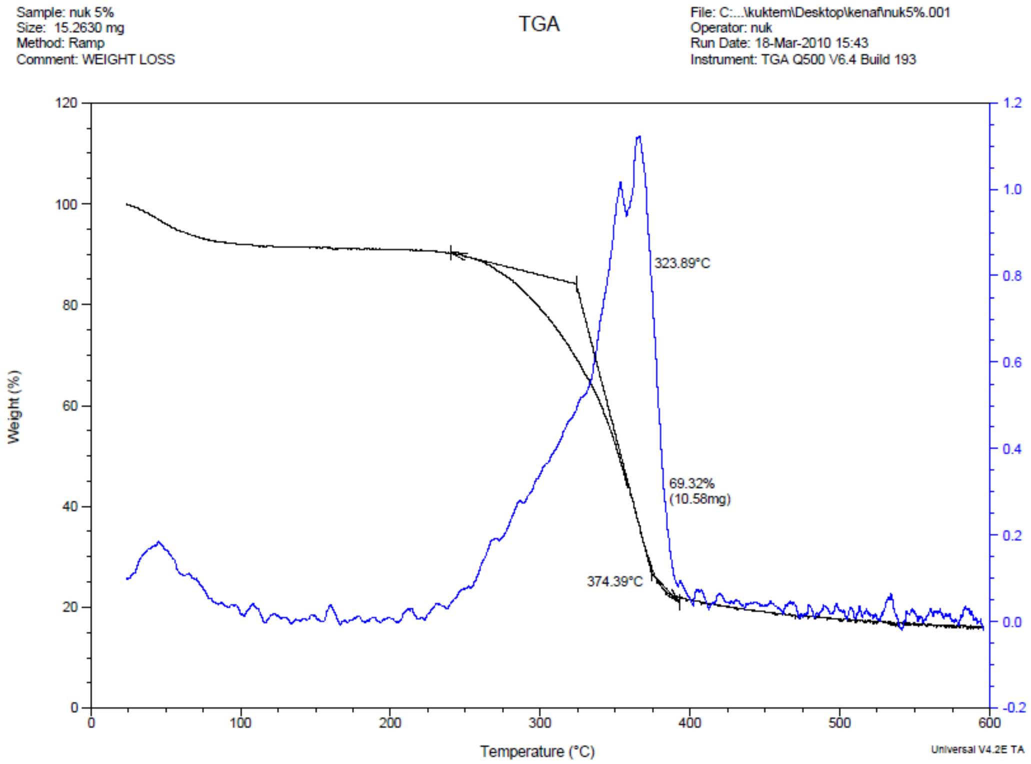


Figure 4.2: Decomposition profile of 5% NaOH treated EFB fiber

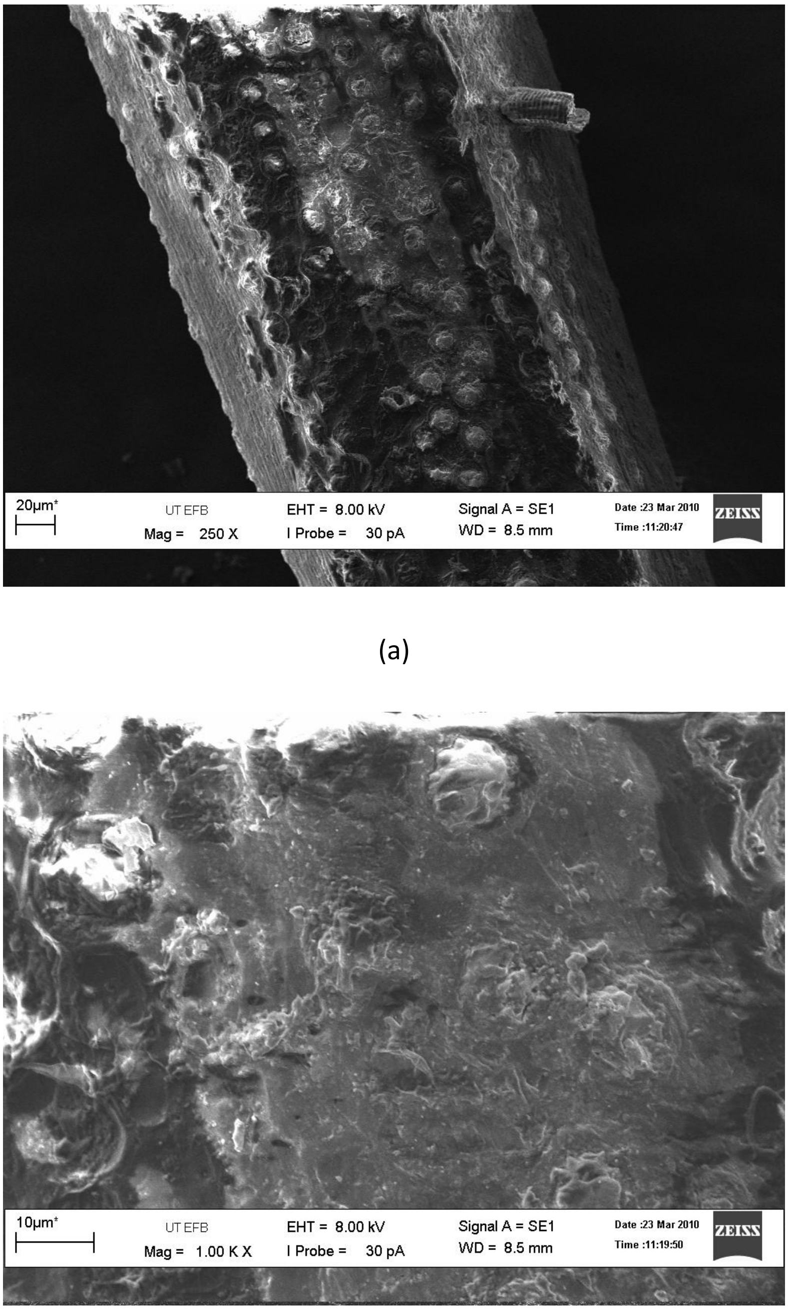
4.2.1 Discussion for TGA result:

Table 4.3: Summary table from TGA analysis graph

Temperature (^{0}C)	**Untreated (weight %)**	**5% NaOH (weight %)**
0	100.0	100.0
300	69.0	78.0
500	0.0	17.0

In TGA test only two tests are run to determine the effect of alkaline treatment process .From the result. We can compare that alkaline treatment process had bring a good effect to the thermal properties of fiber where it has increase the resistance of fiber to the heat. From Untreated fiber graph we can see that at first the shape of the graph is in horizontal line at 100^{0}C - 280 ^{0}C generally. It because of the heat was removing all the moisture content in the fiber. It is also same with the 5% concentration of NaOH fiber and at 100^{0}C - 323 ^{0}C we the graph are in horizontal line. From untreated fiber graph, after 280 ^{0}C the line of the graph begin moving downward, same with treated 5% concentration of NaOH fiber .This is because of the fiber begin to burn and degrade rapidly at higher temperature that is between 300^{0}C-370^{0}C for treated fiber and 280^{0}C-338^{0}C for untreated fiber. Another comparison is we take three main point of temperature to compare effect of the temperature to the weight percent of both sample. We can see that at 500^{0}C there is 0% of weight percent of untreated fiber compare to 5% concentration of NaOH treated fiber it still have 17% of weight percent. From the result we can conclude that that alkaline treatment process had bring a good effect to the thermal properties of fiber where it has increase the resistance of fiber to the heat.

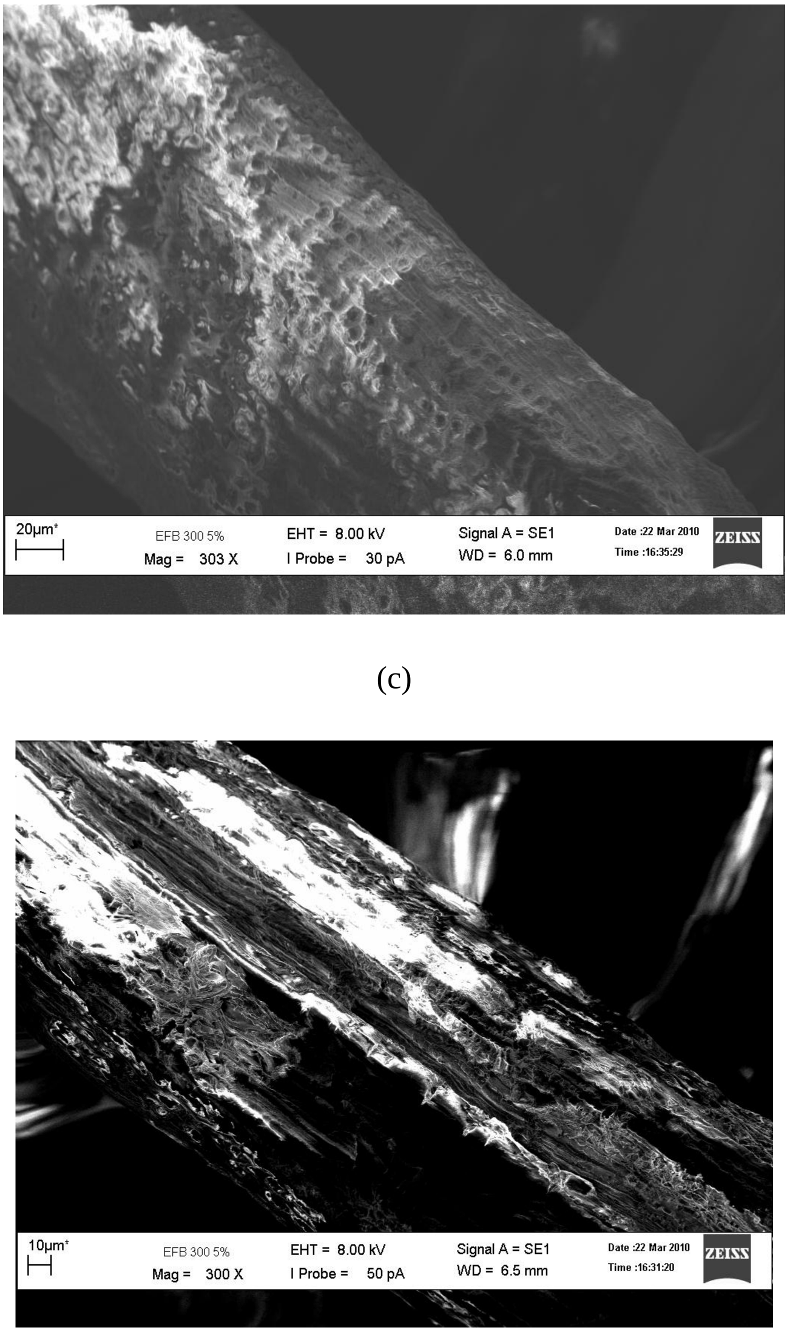
4.3 Result for SEM (scanning electron microscope)



(a)

(b)

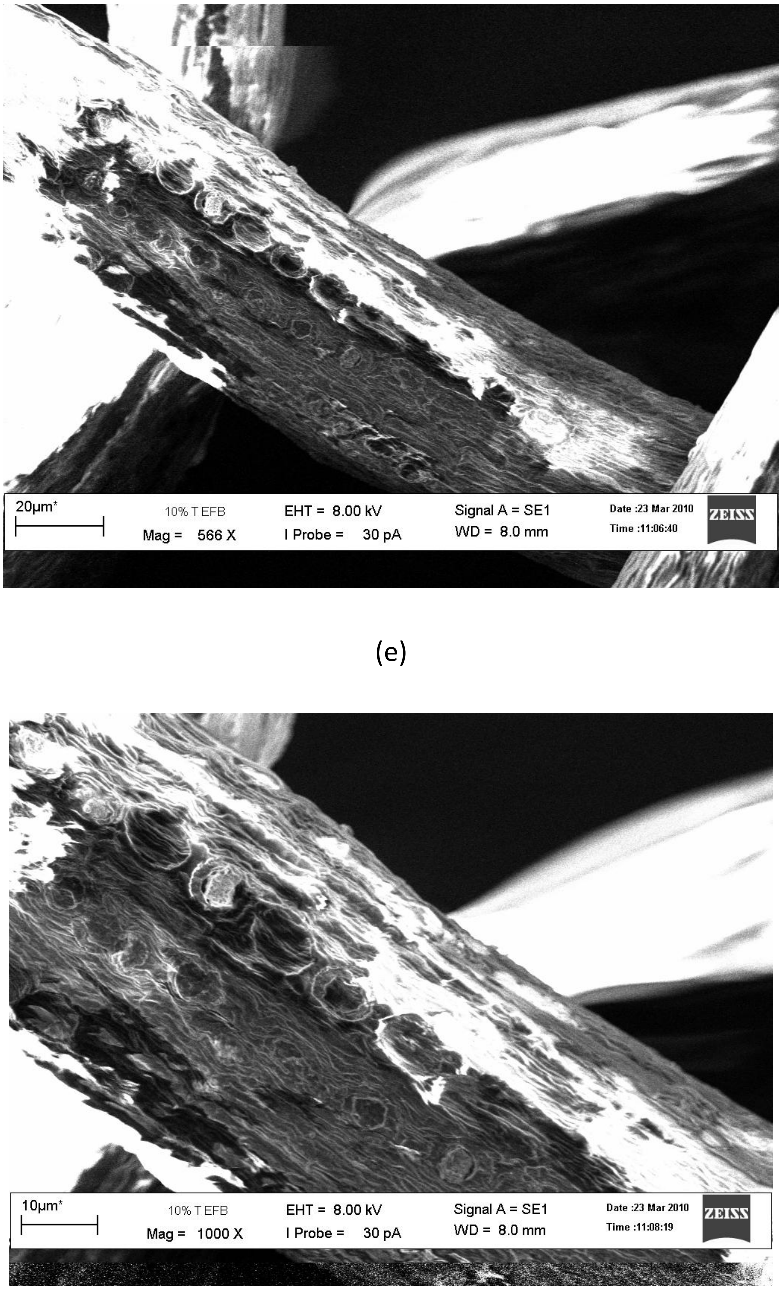
Figure 4.3: SEM untreated fiber surface



(c)

(d)

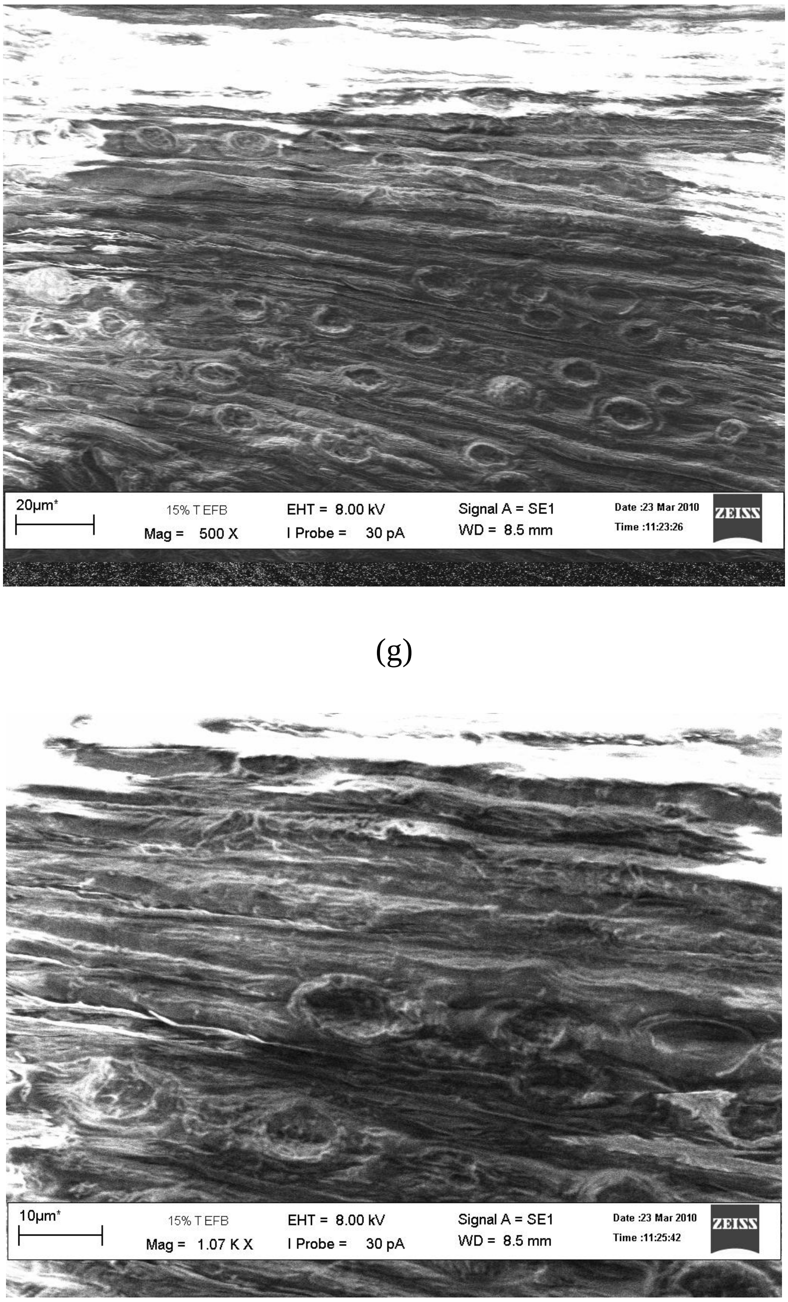
Figure 4.4: SEM 5% NaOH treated fiber surface



(e)

(f)

Figure 4.5: SEM 10% NaOH treated fiber surface



(g)

(h)

Figure 4.6: SEM 15% NaOH treated fiber surface

4.3.1 Discussion for SEM result:

In this test a scanning electron microscopy provides an excellent technique for examining the surface morphology of untreated and treated EFB fiber. It is expected that surface morphology of untreated fiber will be different compared to treated fiber in terms of their level of smoothness and roughness. Therefore, studies of the EFB fiber surface topography could provide vital information on the level of how far the potential of the fiber to make a good bonding with epoxy and the adhesion that would exist between the fiber and the epoxy (matrix) when these all treated and untreated fiber used as reinforcement for these composite. In general, it was seen that the interfacial bonding between fibre and matrix shows good performance. The surface of fibre also rougher than the untreated fibre and it created interlocking mechanism with the surface of matrix. The better adhesion was shown for the increase of the alkali concentrations and soaking times. But this phenomenon is not sufficient to enhance the tensile strength for the samples at high alkali concentration and longer soaking time because the fibre damages could lead to this inferiority in strength property (D. Bachtiar et al. 2008). The magnification is divided by three general magnifications that is 300 times, 500 times and 1000 times. The several several of magnification are done to the scanning process to get the optimum view of surface morphology of these fibers. Figure 4.1 (a) and (b) shows the SEM micrograph of untreated EFB fibers. Clearly, the impurities were observed on the surface of the untreated EFB fiber. On the other hand, figure 4.2 (c) and (d) show EFB fiber after 5% NaOH treatment. In both figures, there are still a lot of impurities that remain on the fiber surface but also we can see some of the surface already clean but not fully complete. It maybe because of 5% concentration of NaOH not sufficient enough to remove all the impurities. Figure 4.3 (e) and (f) shows the SEM micrograph of 10% NaOH , from the figure we can see clearly many hole clean surface morphology, it was indicate that all the impurities was succeeds removed from the fiber. It also same with 4.4 (g) and (h) for 15% NaOH where all the impurities has been removed and cleaner surface with many holes but looks jagged and feel rougher when touched by hand.

4.4 Results for Tensile Test

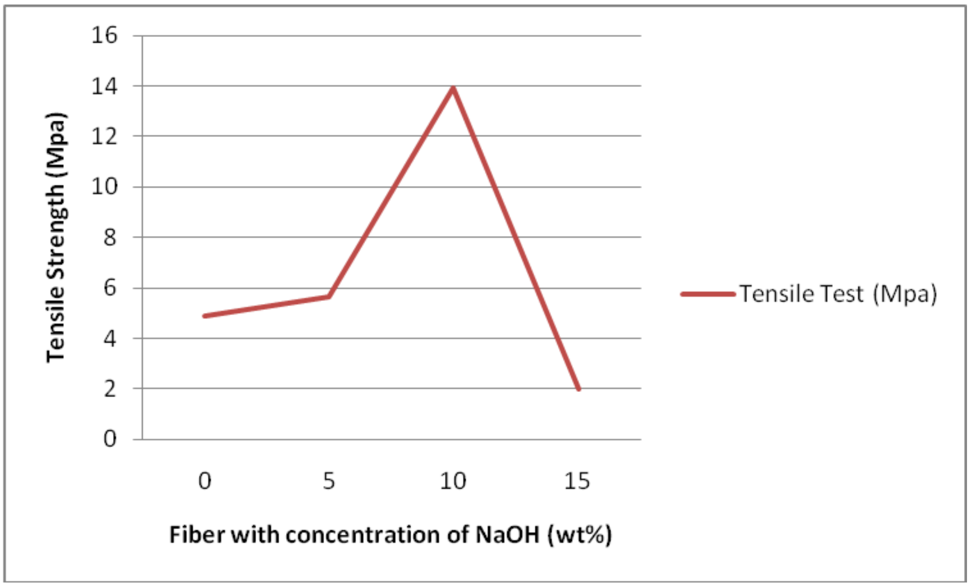


Figure 4.7:Tensile Strength vs Treated Fiber with NaOH Concentration (wt%)

Table 4.4: Result for Tensile Test for treated and untreated EFB

Fiber **(% NaOH)**	**Tensile Strength (MPa)**	**Strain (%)**
0	4.86658	8.2269
5	5.62995	6.87865
10	13.9337	10.8538
15	1.98393	14.3532

4.4.1 Discussion for Tensile test result:

Filler plays an important role in determining the mechanical properties of EFB filled-thermosetting composites. The main important part of making good composites is the bonding mechanism between the filler (EFB) and the matrix (epoxy). The quality of interfacial bonding is determined by several factors, such as the nature of the fiber and polymer component, the fiber aspect ratio, the processing procedure and the treatment of the fiber. In this experiment was expected that the treated fiber tensile strength result will be more than the untreated fiber because of modified surface morphology of fiber when it was treated by alkaline treatment. Alkaline treatment already removed all the impurities and cleaned the surface fiber. Holes that we see are most needed to enhanced the bonding between EFB fiber and epoxy resin. It acts as interlocking mechanism when the epoxy joined the bond. Nature of the fiber itself which are polar nature will strengthen the bonding with epoxy which are non polar. the alkaline treatment has significantly improved the tensile properties of sugar palm fibre reinforced epoxy composites particularly for tensile modulus. The hydrophilic nature of sugar palm fibre has been reduced due to this treatment and therefore has increased the interfacial bonding between matrix and fibres. However, at higher soaking times and alkaline concentrations, the effect of these parameters on tensile strength is not so pronounced because at these conditions, fibre damages may have been dominant (D. Bachtiar et al. 2008).

Tensile properties of composites are presented in table 4.4. As expected with increase the concentration of NaOH will increase the tensile strength of the composites. Fiber incorporation in the polymer matrix caused an interruption stress transferring along the applied forced. From table we can see that alkaline treatment has increase the tensile strength where for 5% (5.63 MPa) and 10% (13.93 MPa) compare to untreated fiber which is 4.87 MPa but at 15% of concentration NaOH the tensile strength result suddenly decrease. It maybe because of the dominant of damage fiber that make the composite is weak due to higher concentration of NaOH. The effect of fiber treatment is its reduces the fiber diameter increase the aspects ratio .Some studies on the alkaline treatment of jute-fiber reported on the removal lignin and hemicelluloses ,which effects the tensile characteristics of the fibers. When hemicelluloses are removed, the interfibrilar region is likely to be less dense than rigid and thereby make the fibrils more capable of rearranging themselves along the direction of tensile formation.

CHAPTER 5

5.0 CONCLUSION & RECOMMENDATION

5.1 Conclusion

From the result we can conclude that the best concentration of NaOH to treat the EFB fibers is 10%. In lignin test we can see that 10% of concentration NaOH is good enough to remove the lignin content from the fiber, even though 15% of NaOH is better but at 10% percent in the better choice for removal efficiency and economic reason. For TGA test it clearly state that alkaline treatment has increased the thermal properties of the fiber compare to the untreated fiber. In other hand, SEM morphological had shown that at 10% NaOH has removed all the impurities and cleaned the surface of fibers. At 15% of NaOH the result are quite same but deferent in term of looks jagged and feel rougher when touched by hand. It was indicate that most of the fiber already damage during the alkaline treatment. For the tensile test, its clearly showed that with increase the alkaline treatment it has increase the Tensile strength of the composite, the highest value is at approximately 14 MPa for 10% of NaOH with epoxy, but at 15% of NaOH it suddenly decrease maybe because of the dominants of damages fibers.

5.2 Recommendation

As for the recommendation there are Many testing can be used to test the properties of composites that not been done during this study because of availability of equipment and limited of research time for example:

1. Heat Deflection Temperature (HDT).
2. Rockwell Hardness.
3. Impact test.

2. Another suggestion is to find the other suitable matrix for thermosetting process for fiber other than Kit Resin Epoxide Qc 8lb H26oz with hardener because the price in the market is quiet expensive.

.

3. Analysis effect on bleaching process using different concentration of H2O2 because in this research all parameters for bleaching process are fixed. There is some research that found that bleaching process has weaker the fiber.

4. Thermoplastic research has not been done by any final year student. So it can be the next research.

5. Effect of fiber loading after optimization process also could be done, but because of limited time and other technical problem, the research cannot been done.

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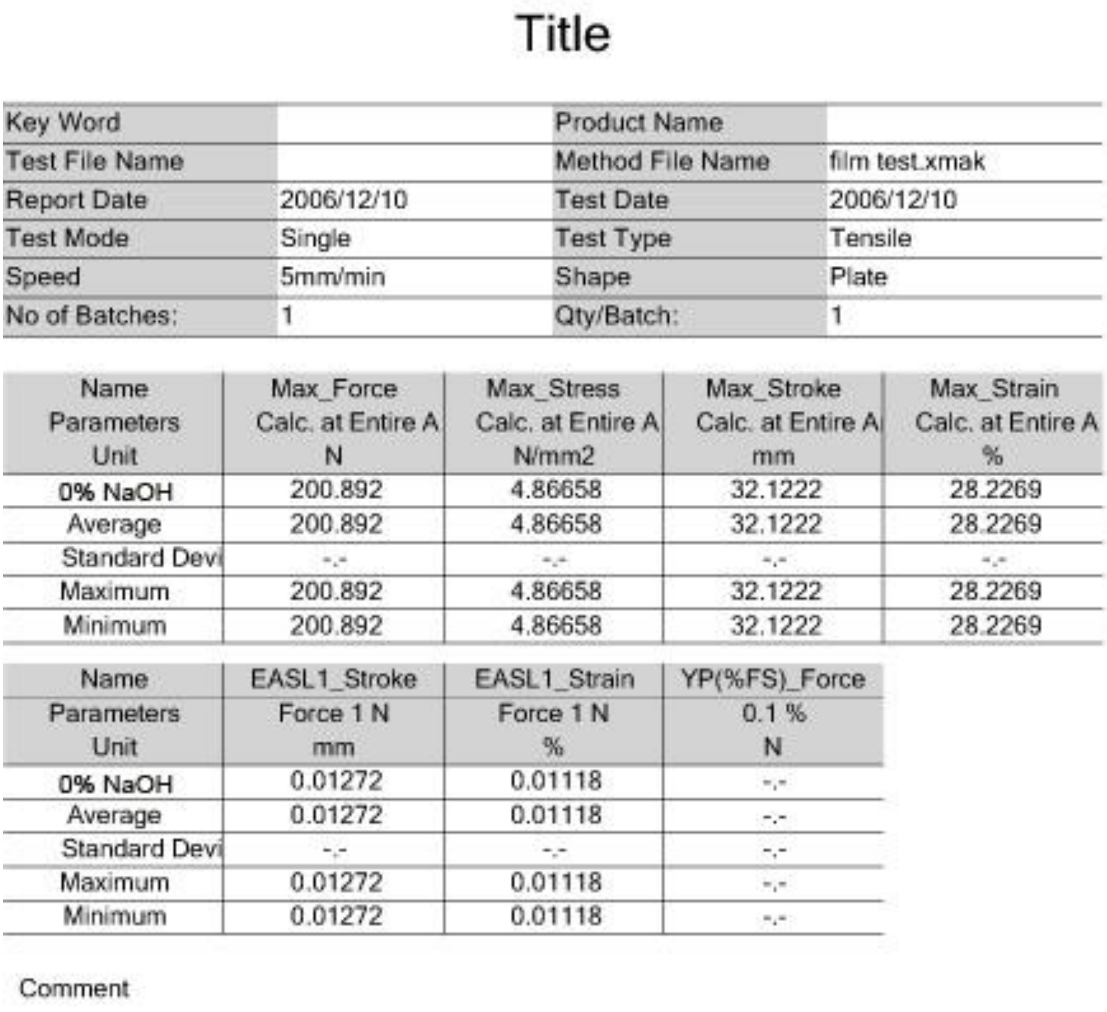
APPENDICES

Tensile strength result for untreated EFB fiber + epoxy



Title

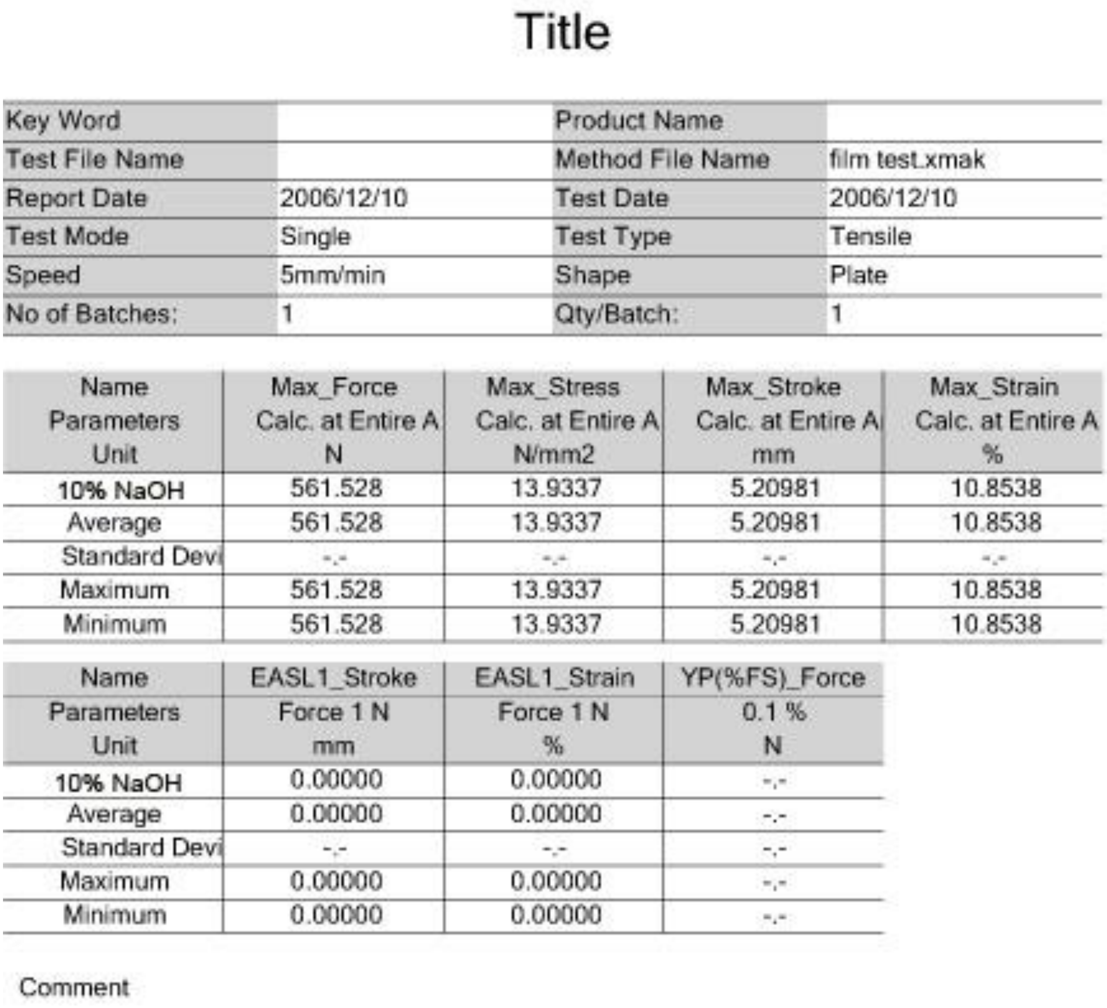
Key Word		Product Name	
Test File Name		Method File Name	film test.xmak
Report Date	2006/12/10	Test Date	2006/12/10
Test Mode	Single	Test Type	Tensile
Speed	5mm/min	Shape	Plate
No of Batches:	1	Qty/Batch:	1

Name Parameters Unit	Max_Force Calc. at Entire A N	Max_Stress Calc. at Entire A N/mm2	Max_Stroke Calc. at Entire A mm	Max_Strain Calc. at Entire A %
0% NaOH	200.892	4.86658	32.1222	28.2269
Average	200.892	4.86658	32.1222	28.2269
Standard Devi	-.-	-.-	-.-	-.-
Maximum	200.892	4.86658	32.1222	28.2269
Minimum	200.892	4.86658	32.1222	28.2269

Name Parameters Unit	EASL1_Stroke Force 1 N mm	EASL1_Strain Force 1 N %	YP(%FS)_Force 0.1 % N
0% NaOH	0.01272	0.01118	-.-
Average	0.01272	0.01118	-.-
Standard Devi	-.-	-.-	-.-
Maximum	0.01272	0.01118	-.-
Minimum	0.01272	0.01118	-.-

Comment

Tensile strength result for 10% NaOH EFB fiber + epoxy



Title

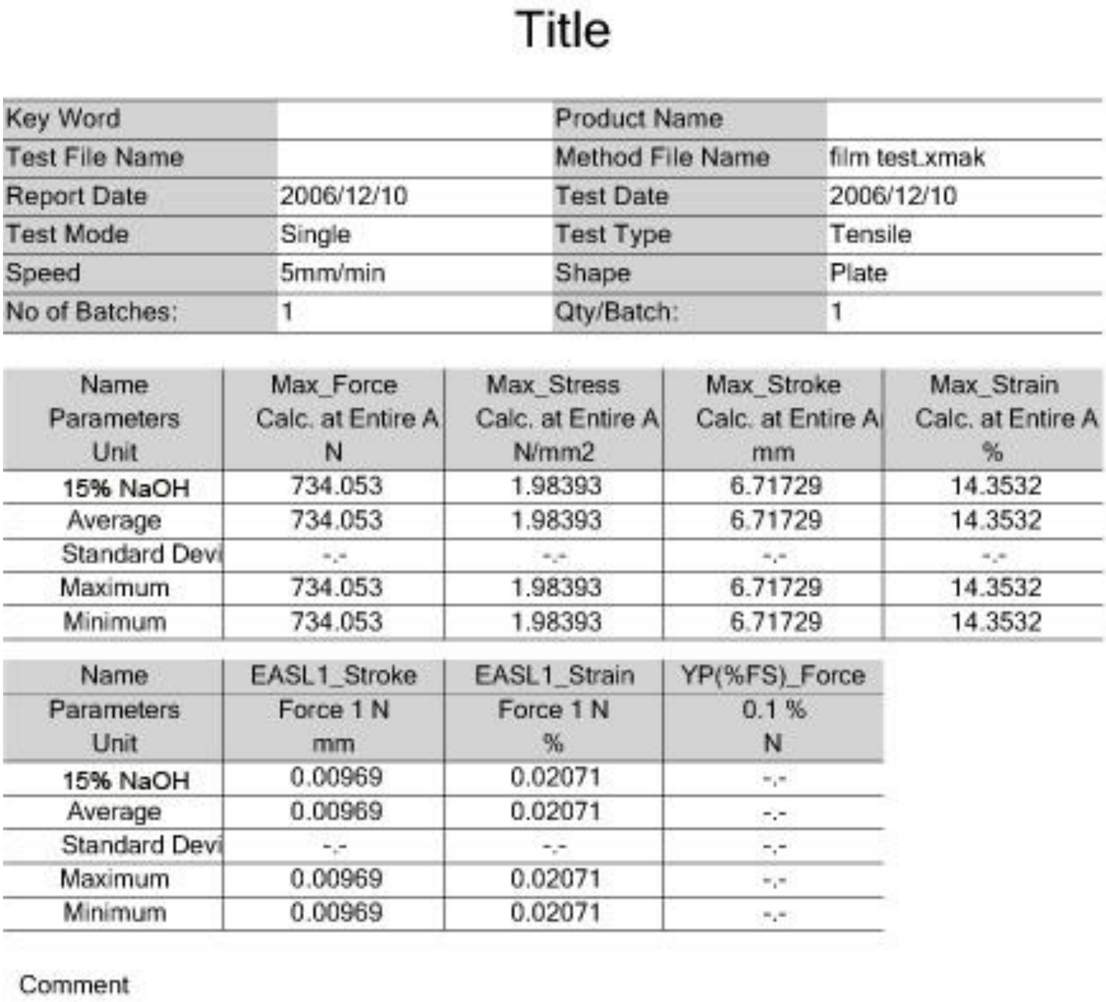
Key Word		Product Name	
Test File Name		Method File Name	film test.xmak
Report Date	2006/12/10	Test Date	2006/12/10
Test Mode	Single	Test Type	Tensile
Speed	5mm/min	Shape	Plate
No of Batches:	1	Qty/Batch:	1

Name Parameters Unit	Max_Force Calc. at Entire A N	Max_Stress Calc. at Entire A N/mm2	Max_Stroke Calc. at Entire A mm	Max_Strain Calc. at Entire A %
10% NaOH	561.528	13.9337	5.20981	10.8538
Average	561.528	13.9337	5.20981	10.8538
Standard Devi	-.-	-.-	-.-	-.-
Maximum	561.528	13.9337	5.20981	10.8538
Minimum	561.528	13.9337	5.20981	10.8538

Name Parameters Unit	EASL1_Stroke Force 1 N mm	EASL1_Strain Force 1 N %	YP(%FS)_Force 0.1 % N
10% NaOH	0.00000	0.00000	-.-
Average	0.00000	0.00000	-.-
Standard Devi	-.-	-.-	-.-
Maximum	0.00000	0.00000	-.-
Minimum	0.00000	0.00000	-.-

Comment

Tensile strength result for 15% NaOH EFB fiber + epoxy



Title

Key Word		Product Name	
Test File Name		Method File Name	film test.xmak
Report Date	2006/12/10	Test Date	2006/12/10
Test Mode	Single	Test Type	Tensile
Speed	5mm/min	Shape	Plate
No of Batches:	1	Qty/Batch:	1

Name Parameters Unit	Max_Force Calc. at Entire A N	Max_Stress Calc. at Entire A N/mm2	Max_Stroke Calc. at Entire A mm	Max_Strain Calc. at Entire A %
15% NaOH	734.053	1.98393	6.71729	14.3532
Average	734.053	1.98393	6.71729	14.3532
Standard Devi	-.-	-.-	-.-	-.-
Maximum	734.053	1.98393	6.71729	14.3532
Minimum	734.053	1.98393	6.71729	14.3532

Name Parameters Unit	EASL1_Stroke Force 1 N mm	EASL1_Strain Force 1 N %	YP(%FS)_Force 0.1 % N
15% NaOH	0.00969	0.02071	-.-
Average	0.00969	0.02071	-.-
Standard Devi	-.-	-.-	-.-
Maximum	0.00969	0.02071	-.-
Minimum	0.00969	0.02071	-.-

Comment

REINFORCEMENT OF PLASTIC USING EMPTY FRUIT BUNCH (EFB) OF PALM OIL WASTE

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Abstract

The use of natural fiber as a reinforcement in polymer composites are getting so much attention and widely used for technical application in automotive , furniture, aerospace ,packaging and others industries. demand and attraction for alternatively material from renewable resource are incredibly increased. Awareness the come out from precision analysis in many aspects for example safety, environmental impact, health and cost saving for composites production had produce one new idea in finding an alternative way to replace the limited resource material like synthetic material. The environmental issue and lower cost for natural fiber and lignocelluloses resource had attract many researcher in the entire world to make this materials as a reinforce material in composite engineering. The main resource is get from agriculture sector that produce as a waste like grain husk, pineapple leaves, kenaf, jut and coir. The objective of this research is to determine the effect of alkaline treatment on this fiber, to produce high quality fiber by treatment process and to find the effect of natural fiber reinforcement with epoxy (plastic).Method that was used in making these plastic reinforcement composites are thermosetting process where the liquefy epoxy resin will be combine with empty fruit bunch (EFB) of oil palm fiber with hot press equipment. The empty fruit bunch fiber will be treat first with alkaline treatment to remove the lignin contain and increase the surface roughness. Alkali treatment also can make fiber more hydrophobic in order to get good interfacial adhesion between fiber and thermoset polymer matrix. The resulted are 10% treatment with NaOH give the best result from effective and economic side where provide tensile strength of 14.9 MPa for 10% fiber loading where it can be used for structural applications.

Abstrak

Penggunaan serat alam sebagai penguat dalam komposit polimer mendapat begitu banyak perhatian dan banyak digunakan untuk aplikasi teknikal di otomotif, furnitur, aerospace, bungkusan dan industri lain. permintaan dan daya tarikan untuk bahan alternatif dari sumber daya terbarukan yang sangat meningkat. Kesedaran keluar dari analisis precision dalam banyak aspek keselamatan contohnya, kesan persekitaran, kesihatan dan penjimatan kos pengeluaran komposit telah menghasilkan satu idea baru dalam mencari cara alternatif untuk menggantikan bahan sumber daya terbatas seperti bahan sintetik. Isu persekitaran dan kos yang lebih rendah untuk serat alam dan sumber daya lignocelluloses telah menarik banyak penyelidik di seluruh dunia untuk membuat bahan ini sebagai bahan menguatkan teknik komposit. Sumber daya utama adalah mendapatkan dari sektor pertanian yang menghasilkan sebagai sisa seperti kulit gandum, daun nenas, Kenaf, unjuran dan pad. Tujuan dari penelitian ini adalah untuk menentukan pengaruh perlakuan alkali pada serat ini, untuk menghasilkan serat berkualiti tinggi oleh proses rawatan dan untuk mengetahui pengaruh penguat serat alami dengan epoxy (plastik). Kaedah yang digunakan dalam membuat komposit plastik thermosetting penguatan proses dimana mencairkan epoksi resin akan menggabungkan dengan tandan buah kosong (TKS) dari serat kelapa sawit dengan peralatan tekan panas. Serat tandan buah kosong akan memperlakukan pertama dengan perlakuan alkali untuk menghilangkan lignin mengandung dan meningkatkan kekasaran permukaan. perlakuan alkali juga boleh membuat lebih banyak serat hidrofob untuk mendapatkan adhesi antar muka yang baik antara serat dan matriks polimer termoset. Adalah perlakuan tersebut menghasilkan 10% dengan NaOH memberikan hasil yang terbaik dari sisi ekonomi yang berkesan dan mana memberikan kekuatan tarik 14,9 MPa selama 10 loading% serat di tempat yang boleh digunakan untuk aplikasi struktur.

Keywords: Empty Fruit bunch of Oil palm,epoxy resin,Tensile strength,Alkaline treatment.

1.0 Introduction

The use of natural fiber as a reinforcement in polymer composites are getting so much attention and widely used for technical application in automotive , furniture, aerospace ,packaging and others industries. Biomass resource from natural fiber is a renewable and easy to get in a lower price compare to synthetic fiber. It has potential to replace the higher cost synthetic fiber like glass fiber, boron, Kevlar and others (bledzki & Gasan , 1999). Lignocelluloses fibers are used as alternative to glass fiber as a reinforcement material in composites has attractive many researchers in this field. That is because the natural fiber offer several of advantages compare to glass fiber from lower cost, ‘high performance/weight’, lighter, easy to process, reactive surface to chemical reaction other than been burn if it is not used anymore.(HPS Abdul khalil et,. 2001). One of lignocelluloses material that is very important with Malaysia scenario is waste from palm oil production industries because Malaysia produces more than 17 million tons of EFB annually. One of the major waste from this industries are empty fruit bunch (EFB).EFB are produced as a side product after the seed is pulled out from it bunch for oil extraction process (Thomas et. Al,. 1997). All the components from palm oil have several potential in many fields for example like plastic-palm oil component (Rozman et al,. 2001), rubber-palm oil components (Ismail et. Al,. 2000). pulp and paper. With advantages those natural fibers have, composites industries from thermoset and thermoplastic are fast develop and increasing.

The environmental issue and lower cost for natural fiber and lignocelluloses resource had attract many researcher in the entire world to make this materials as a reinforce material in composite engineering. The main resource is get from agriculture sector that produce as a waste like grain husk, pineapple leaves, kenaf, jut and coir.

The objective of the research is to to determine the effect of alkaline treatment on this fiber, to produce high quality fiber by treatment process and to find the effect of natural fiber reinforcement with epoxy (plastic). Trough my research I hope it will be give a new information to the community and also giving benefit to IKS (medium and small industries) that want to find new alternative raw material that is cheaper and easy to get in Malaysia especially in polymer industries. It also will give new added value to industrial agriculture industries wastes especially palm oil waste.

2.0 Experimental

2.1 Chemical

Hydrogen peroxide, H2O2.
Natrium hydroxide, NaOH.
Pottasium Iodide, KI.
Sulfuric Acid, H2SO4.
Sodium thiosulfate, $Na_2S_2O_3$.
Acetic Acid, CH_3COOH.
Starch indicator.
Potassium permanganate,KMnO4

2.2 Material

Thermosetting resin.
Kit Resin Epoxide Qc 8lb H26oz with hardener.
Natural Fiber
Empty Fruit Bunch of Palm Oil

2.3 Material Preparation EFB fibers

1. EFB fibers obtained from the supplier from oil palm factory from area Lepar , Pahang are clean with water followed by dried under the sun until it fully dried. The amount of dried fibers used depended on the desired percentage of EFB fibers in the composite.

2. After the EFB had dried. Processes for separate the fiber from their bunch are start. Only good quality fiber are selected and separated from its seed and the other impurities.

3. Next process are grinding process, where the selected fiber about 4 kg are grinded by machine into fine fiber for about 0.8 mm to 10 mm.

Grinded fibers are undergoing sieving process to separate the fiber from dust after the grinded process.

2.4 Fiber Treatment Process.

1. Mercerization Process

Next this fibers are undergo Treatment fiber process with NaOH solution in different concentration of 5% , 10% and 15% in water bath at 70^0C for 3 hour, and washed it with water for several time and dried in oven at 60^0C until it fully dried.

2. Bleaching process

After Mercerization process the fibers are soaked with 0.2% H_2O_2 AT 60^0C for 3 hours in shaking water bath. After that wash it with water for several time and dry in oven at 60^0C until it fully dries.

3. Neutralization Process

Fibers are soaked with Acetic acid 1% at room temperature until it neutral (PH=7) and dry in oven until it fully dried at 60^0C.

2.5 Testing Method

2.5.1 Determination of Kappa Number (KAPPA Test)

1. The 500 ml of 0.1 N potassium permanganate ($KMnO_4$), 4.0 N sulphuric acid (H_2SO_4), 1.0 N potassium iodide (KI), and 0.2 N sodium thiosulphate ($Na_2S_2O_3$) were prepared in the 500 ml conical flask.
2.100 ml of 0.2% starch indicator was prepared by pouring 1 g of starch into 100 ml deionized water.
3. The prepared starch indicator was cooled to room temperature before use.
The 0.5g of each sample was weighted.
4. Then, the 0.5g sample was put into the 500 ml beaker and adds 300 ml of deionized water into the same beaker.
The magnetic stirrer was put into the beaker that contains fiber solution and started to stir the solution.
5.50 ml of 0.1 N potassium permanganate solutions was measured and put into the 250 ml conical flask.
6.50 ml of 4.0 N sulphuric acid solutions was also measured and then mixed with 0.1 N potassium permanganate solutions.
7. The mixture solution was transferred into the beaker that contains fiber solution and the stop watch was started at the same time.
8. The conical flask was rinsed with 100 ml deionized water and was poured into the reaction beaker. The temperature of the reaction solution was measured.
9. After 10 minutes, the chemical reaction in the reaction beaker was stopped by adding of 10 ml 1.0 N potassium iodide solution.
10. Then, the free iodide was titrated with 0.2 N sodium thiosulphate solutions.
11. A few drops starch indicator is added into the reaction beaker when the color of the solution was changed to light yellow.
12. The titration process was stopped when the color of the solution in the reaction beaker becomes colorless.
13. The volume of 0.2 N sodium thiosulphate solutions used for the titration process was measured.
14. This experiment was repeated for blank solution with the same method but without using kenaf fiber.

2.5.2 Scanning Electron Microscope (SEM)

Figure 3.0: SEM micrograph (Carl zeiss evo 50)

1. SEM (scanning electron microscope) to determine the morphological structure of treated and untreated fiber.

Method:

a. Few sample of clean fiber untreated, 5% NaOH, 10% NaOH, and 15% NaOH are put in scanning tray.

b. A surface of the specimen was mounted on metal stubs by double-faced tape and coated with a thin layer of gold (Au).Tray are put into SEM scanning chamber and the detail structure can been seen by adjusted the optimum magnification of lens. Analyses are base on morphological structure.

2.5.3 Thermal gravimetric analysis (TGA)

Figure 3.1: TGA (Thermal gravimetric analysis) Q500

1. TGA (Thermal gravimetric analysis) to determine the thermal properties of treated and untreated fiber.

Method:

1. All 4 trays are calibrated first.
2. Few sample of clean fiber untreated, 5% NaOH, 10% NaOH, and 15% NaOH are put in tray.
3. Range of temperature is set between 30^0C- 600^0C and rate of heating are 10^0C/ min.

2.6 Fabrication process.

Next these fibers 5%, 10%, 15% are undergoing fabrication process by thermosetting process using Hot Press equipment in laboratory to get approximately 0.3 cm in thickness mat.

1. The EFB fibers were mix with epoxy as a resin by 5:1 by volume ratio of hardener with epoxy 2.The dimension of the square mat was approximately 20.0 cm^2.

3. The ratio between EFB and epoxy resin are 1:9 that was 10% from the overall volume.

4. The composite are cut into standard shape for tensile and strength test.

5. The composite board will undergo Tensile and Strength tests. The best composites are being determined

3.0 RESULTS AND DISCUSSION

3.1 Kappa Test Result

Table 4.1:1st Trial of Kappa Test

Conc NaOH (%)	**$Na_2S_20_3$ (ml)**	**p**	**f**	**kappa number**
0	17.5	65.8	1.035	136.206
5	23.7	53.4	1.006	107.4408
10	24.6	51.6	1.002	103.4064
15	25.7	49.4	0.994	98.2072

Table 4.2:2nd Trial of Kappa Test

Conc NaOH (%)	**$Na_2S_20_3$ (ml)**	**p**	**f**	**kappa number**
0	15.3	70.2	1.044	146.5776
5	23.6	53.6	1.037	121.1664
10	25.1	50.6	1.035	104.742
15	26.7	47.4	1.206	111.3288

3.1.1 Discussion for Kappa test result

Several standardized tests have been developed to quantify the degree to which gum associated with cellulose has been hydrolyzed. Such tests are predicated on the relative quantity of non-hydrolyzed lignin that remains in natural association with a sample quantity of water-washed pulp. The "Kappa" Number test, defined by TAPPI Standard T-236 OS-76 determines the volumetric quantity of 0.1 Normal potassium permanganate solution consumed by 1 gram of washed pulp in 10 minutes at 25° C. The "Kappa" Number is 50% of the permanganate volume, in milliters, consumed. The percent of lignin remaining in association with the pulp is lignin %=0.147×"Kappa" Number Another such residual lignin test is the "K" Number or "Permanganate" Number test which is a specialized permutation or abbreviation of the "Kappa" Number test.

Traditionally, "Kappa" Number and "K" Number tests are performed manually in a chemical laboratory. More recently, automated instruments have been developed to perform the tests automatically: either from pulp "grab" samples from the process flow stream at the washers, for example, or from pulp samples taken "on-line" from a digester blow line. In either case, these automatic "Kappa" Number or "K" Number instruments are computer controlled electro-mechanical devices that are required to operate in hostile environments. Consequently, such "Kappa" Number or "K" Number instruments are subject to calibration drift.

The prior practice of "Kappa" Number or "K" Number instrument calibration required that a single pulp sample batch be "Kappa" Number or "K" Number tested in both the instrument and the laboratory. The laboratory result was taken as the control test, and the instrument result was adjusted to correspond to it. This calibration procedure was both slow and expensive (James J. Foster et al. 1993).

From first trial the kappa number for 15% of NaOH is 98.2072 which are the lowest kappa number compare to 10% of NaOH (103.4064) followed by 5% of NaOH (107.4408) and the untreated fiber (136.206).Second trial it has showed that kappa number for 10% of NaOH is 104.742 which are the lowest kappa number compare to 15% of NaOH (111.3288) followed by 5% of NaOH (121.1664) and the untreated fiber (146.5776).From 1st and 2nd trial we can summarized that at concentration 10% and 15% of NaOH give the lowest kappa number. According to the standard of Kappa Test, the lower the kappa numbers determine the lower content of lignin. From the result we can concluded that at concentration of 10% it is no good enough to remove all lignin content. Actually the kappa number that I get is very big compared to the standard that usually in range below 100. This experiment can be fixed make more test to get the better result. From my analysis the higher kappa number maybe due to a effect of starch indicator that must be add after the solution are turn in clearly light yellow.

3.2 Result for TGA (Thermal gravimetric analysis)

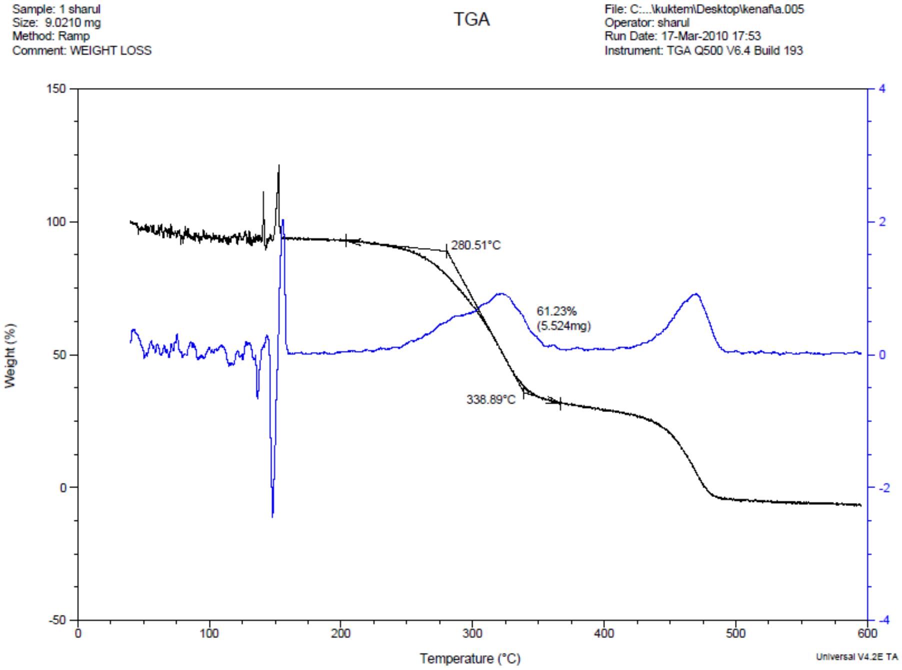


Figure 4.1: Decomposition profile of untreated EFB fiber

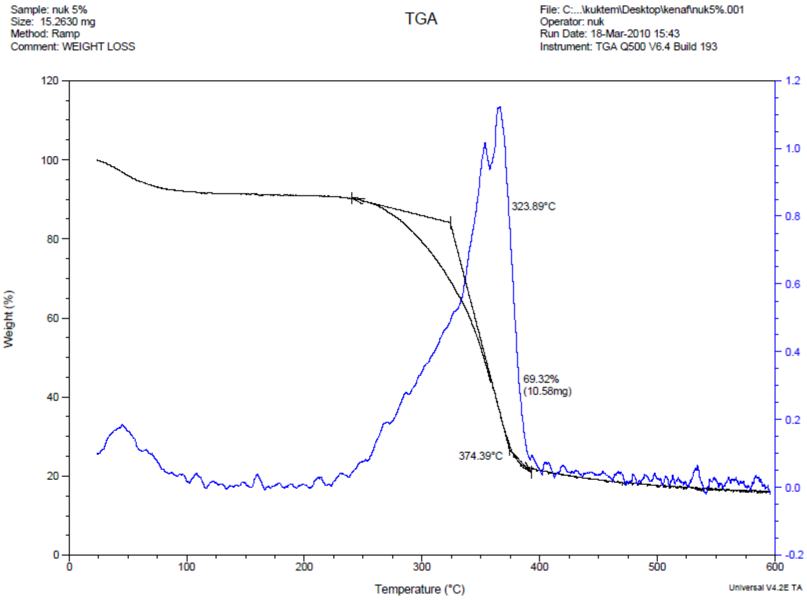


Figure 4.2: Decomposition profile of 5% NaOH treated EFB fiber

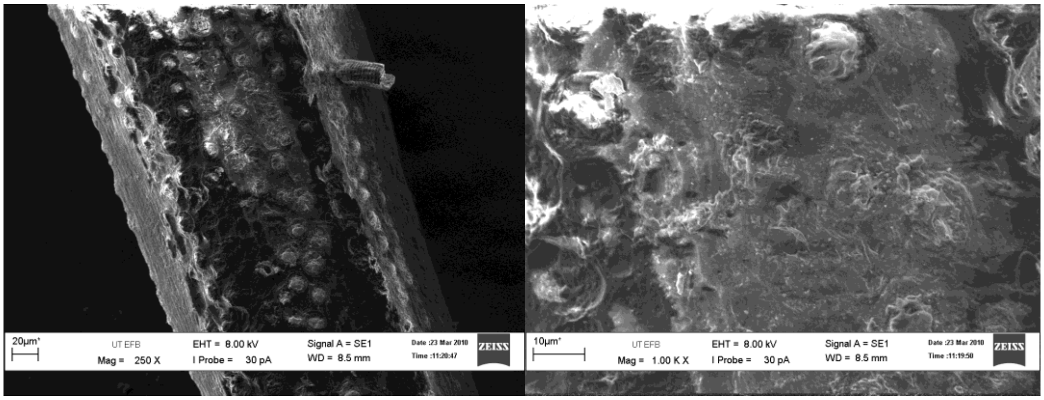
3.2.1 Discussion for TGA result:

Table 4.3: Summary table from TGA analysis graph

Temperature (^{0}C)	**Untreated (weight %)**	**5% NaOH (weight %)**
0	100.0	100.0
300	69.0	78.0
500	0.0	17.0

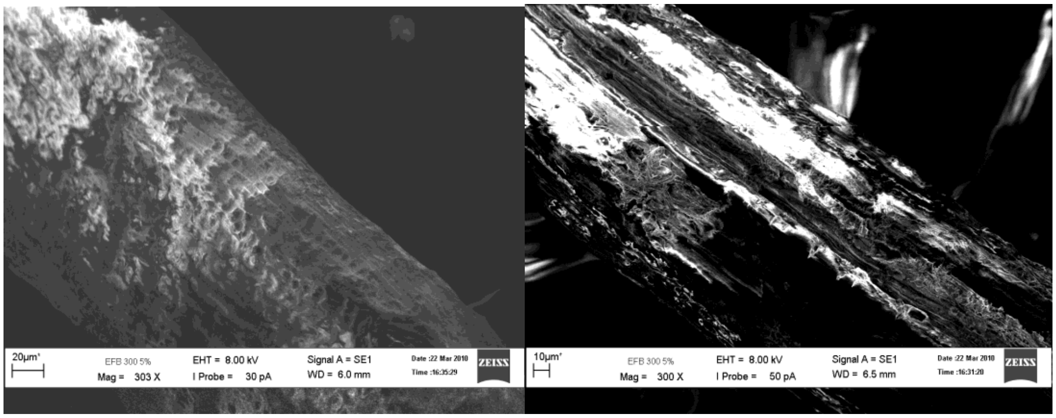
In TGA test only two tests are run to determine the effect of alkaline treatment process .From the result. We can compare that alkaline treatment process had bring a good effect to the thermal properties of fiber where it has increase the resistance of fiber to the heat. From Untreated fiber graph we can see that at first the shape of the graph is in horizontal line at 100^{0}C - 280 ^{0}C generally. It because of the heat was removing all the moisture content in the fiber. It is also same with the 5% concentration of NaOH fiber and at 100^{0}C - 323 ^{0}C we the graph are in horizontal line. From untreated fiber graph, after 280 ^{0}C the line of the graph begin moving downward, same with treated 5% concentration of NaOH fiber .This is because of the fiber begin to burn and degrade rapidly at higher temperature that is between 300^{0}C-370^{0}C for treated fiber and 280^{0}C-338^{0}C for untreated fiber. Another comparison is we take three main point of temperature to compare effect of the temperature to the weight percent of both sample. We can see that at 500^{0}C there is 0% of weight percent of untreated fiber compare to 5% concentration of NaOH treated fiber it still have 17% of weight percent. From the result we can conclude that that alkaline treatment process had bring a good effect to the thermal properties of fiber where it has increase the resistance of fiber to the heat.

3.3 Result for SEM (scanning electron microscope)



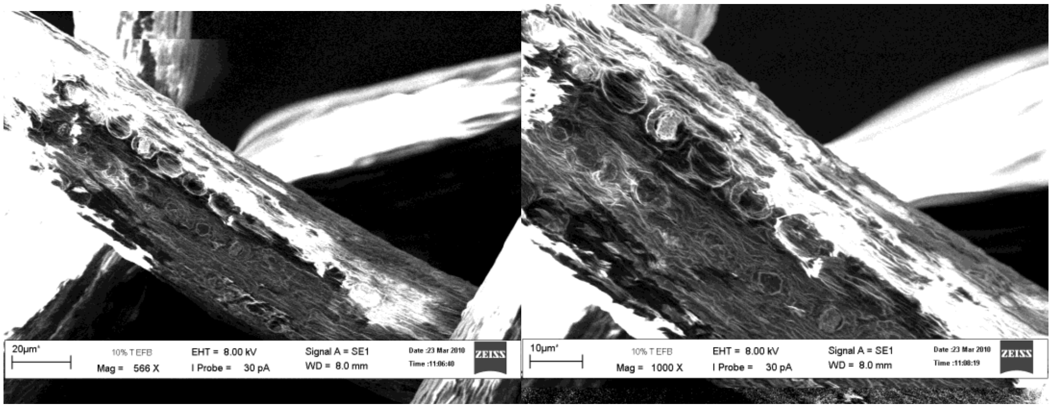
(a) (b)

Figure 4.3: SEM untreated fiber surface



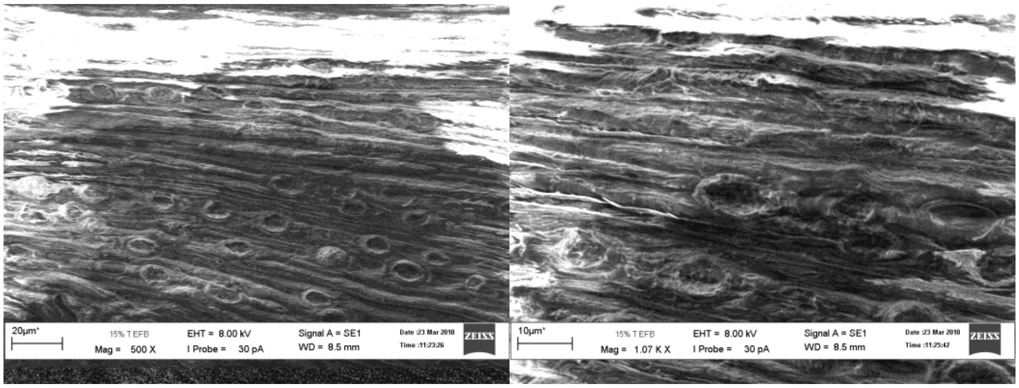
(c) (d)

Figure 4.4: SEM 5% NaOH treated fiber surface



(e) (f)

Figure 4.5: SEM 10% NaOH treated fiber surface



(g) (h)

Figure 4.6: SEM 15% NaOH treated fiber surface

3.3.1 Discussion for SEM result:

In this test a scanning electron microscopy provides an excellent technique for examining the surface morphology of untreated and treated EFB fiber. It is expected that surface morphology of untreated fiber will be different compared to treated fiber in terms of their level of smoothness and roughness. Therefore, studies of the EFB fiber surface topography could provide vital information on the level of how far the potential of the fiber to make a good bonding with epoxy and the adhesion that would exist between the fiber and the epoxy (matrix) when these all treated and untreated fiber used as reinforcement for these composite. In general, it was seen that the interfacial bonding between fibre and matrix shows good performance. The surface of fibre also rougher than the untreated fibre and it created interlocking mechanism with the surface of matrix. The better adhesion was shown for the increase of the alkali concentrations and soaking times. But this phenomenon is not sufficient to enhance the tensile strength for the samples at high alkali concentration and longer soaking time because the fibre damages could lead to this inferiority in strength property (D. Bachtiar et al. 2008). The magnification is divided by three general magnifications that is 300 times, 500 times and 1000 times. The several several of magnification are done to the scanning process to get the optimum view of surface morphology of these fibers. Figure 4.1 (a) and (b) shows the SEM micrograph of untreated EFB fibers. Clearly, the impurities were observed on the surface of the untreated EFB fiber. On the other hand, figure 4.2 (c) and (d) show EFB fiber after 5% NaOH treatment. In both figures, there are still a lot of impurities that remain on the fiber surface but also we can see some of the surface already clean but not fully complete. It maybe because of 5% concentration of NaOH not sufficient enough to remove all the impurities. Figure 4.3 (e) and (f) shows the SEM micrograph of 10% NaOH , from the figure we can see clearly many hole clean surface morphology, it was indicate that all the impurities was succeeds removed from the fiber. It also same with 4.4 (g) and (h) for 15% NaOH where all the impurities has been removed and cleaner surface with many holes but looks jagged and feel rougher when touched by hand.

3.4 Results for Tensile Test

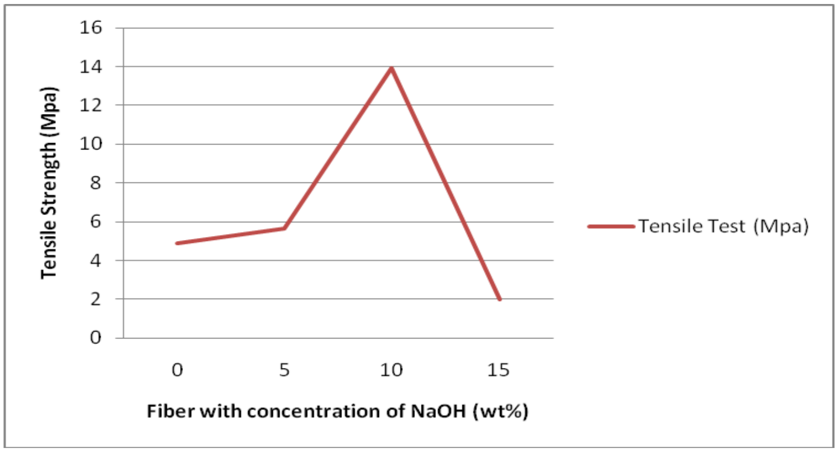


Figure 4.7:Tensile Strength vs Treated Fiber with NaOH Concentration (wt%)

Table 4.4: Result for Tensile Test for treated and untreated EFB

Fiber (% NaOH)	Tensile Strength (MPa)	Strain (%)
0	4.86658	8.2269
5	5.62995	6.87865
10	13.9337	10.8538
15	1.98393	14.3532

3.4.1 Discussion for Tensile test result:

Filler plays an important role in determining the mechanical properties of EFB filled-thermosetting composites. The main important part of making good composites is the bonding mechanism between the filler (EFB) and the matrix (epoxy). The quality of interfacial bonding is determined by several factors, such as the nature of the fiber and polymer component, the fiber aspect ratio, the processing procedure and the treatment of the fiber. In this experiment was expected that the treated fiber tensile strength result will be more than the untreated fiber because of modified surface morphology of fiber when it was treated by alkaline treatment. Alkaline treatment already removed all the impurities and cleaned the surface fiber. Holes that we see are most needed to enhanced the bonding between EFB fiber and epoxy resin. It acts as interlocking mechanism when the epoxy joined the bond. Nature of the fiber itself which are polar nature will strengthen the bonding with epoxy which are non polar. the alkaline treatment has significantly improved the tensile properties of sugar palm fibre reinforced epoxy composites particularly for tensile modulus. The hydrophilic nature of sugar palm fibre has been reduced due to this treatment and therefore has increased the interfacial bonding between matrix and fibres. However, at higher soaking times and alkaline concentrations, the effect of these parameters on tensile strength is not so pronounced because at these conditions, fibre damages may have been dominant (D. Bachtiar et al. 2008).

Tensile properties of composites are presented in table 4.4. As expected with increase the concentration of NaOH will increase the tensile strength of the composites. Fiber incorporation in the polymer matrix caused an interruption stress transferring along the applied forced. From table we can see that alkaline treatment has increase the tensile strength where for 5% (5.63 MPa) and 10% (13.93 MPa) compare to untreated fiber which is 4.87 MPa but at 15% of concentration NaOH the tensile strength result suddenly decrease. It maybe because of the dominant of damage fiber that make the composite is weak due to higher concentration of NaOH. The effect of fiber treatment is its reduces the fiber diameter increase the aspects ratio .Some studies on the alkaline treatment of jute-fiber reported on the removal lignin and hemicelluloses ,which effects the tensile characteristics of the fibers. When hemicelluloses are removed, the interfibrilar region is likely to be less dense than rigid and thereby make the fibrils more capable of rearranging themselves along the direction of tensile formation.

4.0 CONCLUSION & RECOMMENDATION

4.1 Conclusion

From the result we can conclude that the best concentration of NaOH to treat the EFB fibers is 10%. In lignin test we can see that 10% of concentration NaOH is good enough to remove the lignin content from the fiber, even though 15% of NaOH is better but at 10% percent in the better choice for removal efficiency and economic reason. For TGA test it clearly state that alkaline treatment has increased the thermal properties of the fiber compare to the untreated fiber. In other hand, SEM morphological had shown that at 10% NaOH has removed all the impurities and cleaned the surface of fibers. At 15% of NaOH the result are quite same but deferent in term of looks jagged and feel rougher when touched by hand. It was indicate that most of the fiber already damage during the alkaline treatment. For the tensile test, its clearly showed that with increase the alkaline treatment it has increase the Tensile strength of the composite, the highest value is at approximately 14 MPa for 10% of NaOH with epoxy, but at 15% of NaOH it suddenly decrease maybe because of the dominants of damages fibers.

4.2 Recommendation

As for the recommendation there are Many testing can be used to test the properties of composites that not been done during this study because of availability of equipment and limited of research time for example:

1. Heat Deflection Temperature (HDT).

2. Rockwell Hardness.

3. Impact test.

2. Another suggestion is to find the other suitable matrix for thermosetting process for fiber other than Kit Resin Epoxide Qc 8lb H26oz with hardener because the price in the market is quiet expensive.

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3. Analysis effect on bleaching process using different concentration of H_2O_2 because in this research all parameters for bleaching process are fixed. There is some research that found that bleaching process has weaker the fiber.

4. Thermoplastic research has not been done by any final year student. So it can be the next research.

5. Effect of fiber loading after optimization process also could be done, but because of limited time and other technical problem, the research cannot been done.

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UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: REINFORCEMENT OF PLASTIC USING EMPTY FRUIT BUNCH (EFB) OF PALM OIL WASTE

SESI PENGAJIAN: **2009/2010**

Saya **SHAHRUL ANUAR BIN ABD RAHMAN**

(HURUF BESAR)

mengaku membenarkan kertas projek ini disimpan di Perpustakaan Universiti Malaysia Pahang dengan syarat-syarat kegunaan seperti berikut :

1. Hakmilik kertas projek adalah di bawah nama penulis melainkan penulisan sebagai projek bersama dan dibiayai oleh UMP, hakmiliknya adalah kepunyaan UMP.
2. Naskah salinan di dalam bentuk kertas atau mikro hanya boleh dibuat dengan kebenaran bertulis daripada penulis.
3. Perpustakaan Universiti Malaysia Pahang dibenarkan membuat salinan untuk tujuan pengajian mereka.
4. Kertas projek hanya boleh diterbitkan dengan kebenaran penulis. Bayaran royalti adalah mengikut kadar yang dipersetujui kelak.
5. *Saya membenarkan/tidak membenarkan Perpustakaan membuat salinan kertas projek ini sebagai bahan pertukaran di antara institusi pengajian tinggi.
6. ** Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan).
☑	TIDAK TERHAD	

Disahkan oleh

(TANDATANGAN PENULIS)

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Nama Penyelia

Tarikh: 30 APRIL 2010

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CATATAN:
- * Potong yang tidak berkenaan.
- ** Jika Kertas Projek ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.
- ♦ Tesis ini dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM)

“I hereby declare that I have read this thesis and in my opinion this thesis has fulfilled the qualities and requirements for the award of Degree of Bachelor of Chemical Engineering

Signature : …………………………

Name of Supervisor : Dr. Mohammad Dalour Hossen Beg

Date : …………………………