THE EFFECT OF SURFACE TREATMENT ON PALF REINFORCED VINYL ESTER COMPOSITES

MUHAMMAD FARID ELYMAN BIN ALZAHARI

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DECLARATION

I declare that this project report entitled "The effect of surface treatment on pineapple leaf fibre reinforced vinyl ester composites" is the result of my own work except as cited in the references

Signature : .....

Name of Supervisor : Muhammad Faid

Date : 28/6/2019

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is enough in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant & Maintenance).

Signature : .....

Name of Supervisor : DR NADLENE RAZALI

Date : 3/7/2019

ABSTRACT

Nowadays, the growing of the science and technology is the main problem to the environmental and become very serious all over the world. Researchers are working together to produce the environment-friendly material or also known as a green material in order to solve this critical problem. Researchers have focused the usage of natural fibre to replace synthetic fibre. Natural fibre have a lot of advantages compare with synthetic fibre such as low cost, eco-friendly product and can reduce waste of pineapple leaf. In this research, the objective is to investigate the effect of surface treatment PALF to the vinyl ester reinforcement in terms of mechanical, physical and morphological properties. The parameter use in this research is 5wt% of the fibre loading for untreated and treated of PALF. The chemical treatment use is alkaline treatment which is 6% of NaOH. The sample will be characterized in term of their physical, mechanical and morphological properties. Based on the physical properties, the density of the treated composites was higher due to increase the amount of the fibre in the composites, the treated composites also show good result for moisture content and water absorption. For the mechanical properties, treated composites showed an improvement for tensile and flexural strength. This is because alkaline treatment on the fibre improve the interfacial bonding between fibre and polymer. For morphological analysis, treated composites also has good surface structure because there is no gap between fibre and matrix and less fibre pull-out compared with the untreated composites sample. As the conclusion, alkali treatment on the natural fibre improve the interfacial bonding between fibre and polymer.

ABSTRAK

Pada masa kini, perkembangan sains dan teknologi merupakan masalah utama kepada alam sekitar dan menjadi sangat serius di seluruh dunia. Penyelidik bekerjasama untuk menghasilkan bahan mesra alam atau juga dikenali sebagai bahan hijau untuk menyelesaikan masalah kritikal ini. Penyelidik menumpukan penggunaan serat semula jadi untuk menggantikan serat sintetik. Serat semulajadi mempunyai banyak kelebihan berbanding dengan serat sintetik seperti kos rendah, produk mesra alam dan dapat mengurangkan pembaziran daun nanas. Dalam penyelidikan ini, objektifnya adalah untuk mengkaji kesan rawatan permukaan serat nanas bercampur dengan vinyl ester dari segi sifat mekanikal, fizikal dan morfologi. Parameter yang digunakan dalam kajian ini ialah 5wt% daripada beban serat untuk PALF yang tidak dirawat dan dirawat. Penggunaan rawatan kimia adalah rawatan alkali iaitu 6% NaOH. Ujian sampel dibahagikan kepada tiga fasa iaitu ujian fizikal, ujian mekanikal dan analisis morfologi. Berdasarkan ujian fizikal, ketumpatan komposit terawat adalah lebih tinggi kerana meningkatkan jumlah serat dalam komposit, komposit yang dirawat juga menunjukkan hasil yang baik untuk kandungan lembapan dan penyerapan air. Untuk ujian mekanikal, komposit yang dirawat mempunyai bacaan yang lebih tinggi untuk kekuatan tegangan dan lentur. Ini adalah kerana rawatan alkali pada serat meningkatkan ikatan antara antara serat dan polimer. Untuk analisis morfologi, komposit terawat juga mempunyai struktur permukaan yang baik kerana tiada jurang antara serat dan matriks dan kurang jumlah serat yang teertarik berbanding dengan sampel komposit yang tidak dirawat. Sebagai kesimpulan, rawatan alkali pada serat semulajadi adalah kaedah yang sangat berkesan untuk menghasilkan produk serat semulajadi berkualiti tinggi.

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LIST OF ABBREVIATION

Abbreviation

PALF	Pineapple Leaf Fibre
CFRP	Carbon Fibre Reinforced Polymer
PLA	Polylactic Acid
PP	Polypropylene
PC	Polycarbonate
HIPS	High Impact Polystyrene
VE	Vinyl Esters
SEM	Scanning Electron Microscope.

LIST OF SYMBOLS

Symbol	
NaOH	Sodium Hydroxide
ρ	Density
m	Mass
V	Volume

CHAPTER 1

INTRODUCTION

1.1 Overview of the project

Nowadays, the growing of the science and technology is the main problem to the environmental and become very serious all over the world. Unsafe modern material that can influence an individual's wellbeing, the transfer of the unbiodegradable material, for example, plastic and an Earth-wide temperature boost cause by the nursery impact. Researchers are working together to producing the environment-friendly material or also known as a green material in order to solve this critical problem. Researchers have focused the usage of natural fibre to replace synthetic fibre.

The use of natural fibre can reduce the addiction on non-renewable energy and decrease pollutant emissions. The other advantages is can reduced greenhouse gas emissions and improve the energy recovery(Sanjay and Yogesha, 2017). In term of mechanical properties, natural fibre has low in density and high specific strength and stiffness. Natural fibre has lower cost compared with the synthetic fibre. It is also renewable resources and has low abrasive damage while processing equipment process(K.L. Pickering, M.G. Aruan Efendy, 2016).

Several types of natural fibre has possibilities to become reinforcement materials in composites and replacement for glass(Sgriccia, Hawley and Misra, 2008). Sisal, coir, jute, ramie, pineapple leaf (PALF), and kenaf is the most used of natural fibre in industry.

Pineapple leaf (PALF) has to be selected as a reinforcing material in natural composite products because Malaysia is one of the main world producers of pineapple. However, only the fruit is employed whereas the leaf, whose main content is fibre, is burnt or thrown away. The use of pineapple leave as natural fibre can reduce environmental pollution and can generate extra income for the country especially Malaysia.

Some of the pineapple leaves has been used in the manufacture of yarn, woven fabrics and handmade products. Fibres extracted from pineapple leaves suitable for industrial applications because it is one of the finest fineness indices among the vegetable fibres(Leão *et al.*, 2014). Even the PALF fibre has a lot of advantages in term of their physical properties it still has some flaws. However, there has a separate method to improve the fibres surface to make it suitable for interfacial fibre/matrix bonding. The amount of cellulose in the PALF is about 70-80%wt which is making it having specific modulus and strength(Panyasart *et al.*, 2014).

Vinyl ester is one of the thermosets and resin will be used in this research. Short fibre will be used as reinforced material in this research. To assess the growth of PALF-vinyl ester composites, there are many criteria can be used which is mechanical properties, physical properties and thermal stability.

This study discusses the PALF mechanical and physical properties characteristic after doing a surface treatment of PALF reinforced with thermoset materials. In this research, the PALF was treated using alkali treatment to produce PALF composites that have better physical, mechanical and morphological properties.

1.2 Problem statement

Natural fibre is found abundantly in Malaysia. There are several types of fibre typically used in Malaysia. For example, is kenaf, abaca, oil, pineapple leaves, sugarcane bagasse, and banana. PALF is one of the potential fibre that can replace the synthetic fibre.

In Malaysia, pineapple leaves are one of the available waste materials. Generally, the agriculture industries only utilized pineapple fruit while the leaf is currently being wasted. The most critical part is when the pineapple leaves are treated as agricultural wastes where it either being let composted or burned by farmers. Basically, natural fibre has a lot of advantages over the disadvantages, but it still needs to modify some of the mechanical and physical properties of the natural fibres. The surface modification is important to restructure the hydrophilic characteristic of the natural fibres fibres and become more effective compared with the synthetic fibre.

1.3 Objective

The objective of the project:

1. To investigate the effect of surface treatment on the pineapple leaf fibre reinforced vinyl ester in terms of mechanical, physical and morphological properties.

1.4 Scope of product

In this project, there have four phases need will be carried out in order to have better understanding about pineapple fibre composites in term of physical, mechanical and morphological properties. The first phase this research is PALF is treated with alkali solution and blended with vinyl ester form the composite sample.

The second phase of this research, the composites were prepared. The composites are being fabricated by place the PALF and vinyl ester into the mould and handle using hand lay-up method. Then, insert the samples into the oven to obey the cure cycle of vinyl ester.

The third phase of this project covers the physical and mechanical properties. Physical properties will be characterized by density analysis, water absorption test and moisture content. For mechanical testing covers two types of testing which is a tensile test and flexural test.

The last phase is the most important part of the research where the physical and mechanical properties of PALF were discussed and observed. The chemical treatment was deliberated to investigate which treatment lead to the major improvements in physical and mechanical properties of PALF reinforced vinyl ester. The result of the untreated and treated was compared. All these testing is being done by following the standards involved according to each method.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural fibre composites

In days gone by few decades, the use of natural fibres in composites applications has been increasing. The use of natural fibres is not a modern technology because scientist already used in China and Korea to build a wall in the village by a combination of the straws and mud(Lau *et al.*, 2018). Natural fibres have been chosen by the researchers and scientist because of their eco-friendly and sustainable. Natural fibres convey benefit to many engineering applications, but the worst issues regularly condemned by people in general which is serious environmental problems after disposal of advanced composites as it is hard to be recycled. The used of the carbon fibre reinforced polymer composites (CFRP) create strong strength structure from advanced composites but very high cost of materials for domestic products(Lau *et al.*, 2018). The density and eco-friendly properties of the natural fibre attract many engineering sectors to studied on the improvement of the natural fibre because it can reduce pollution and save the environment.

Natural fibres can be derived from plant, animal, or mineral. Biomedical applications such as implants usually used animal-based fibres as example cocoon silk and spider silks. New bone fixator has been created by Lau et al after done research on the cocoon silk fibre-reinforced Polylactic acid (PLA) to formulated bio-resorbable polymer composites.(Lau *et al.*, 2018).

The next type of natural fibres is plant fibre. Bast fibres, leaf fibres, fruit, seed, wood, and cereal straw is the most used of natural plant in application(Webber, Bhardwaj and Bledsoe, 2002). Among natural fibre, plant fibres are widely used as reinforcement in fibre reinforced composites. It's is do not harm the environment because natural fibres extracted from nature and can be classify as renewable resources. Natural fibres has better specific strength, specific modulus, and lower cost compared with glass fibres. Nowadays, many major components of bio-composite materials like paper, boards, and many structures come from fibres composites.

For the plant-based natural fibres sources, depending on the utilization, two types of fibres class which primary class and second class where the primary class are those plant which grown for their fibre. Sisal, jute, kenaf and hemp classify as primary type of plant but pineapple, oil palm and coir in the second type of plant. The secondary type of plant is where the fibre is producing as a by-product. Figure 2.1 shown that the classification of the natural fibre divided depending upon their region(Thakur, Thakur and Gupta, 2014).

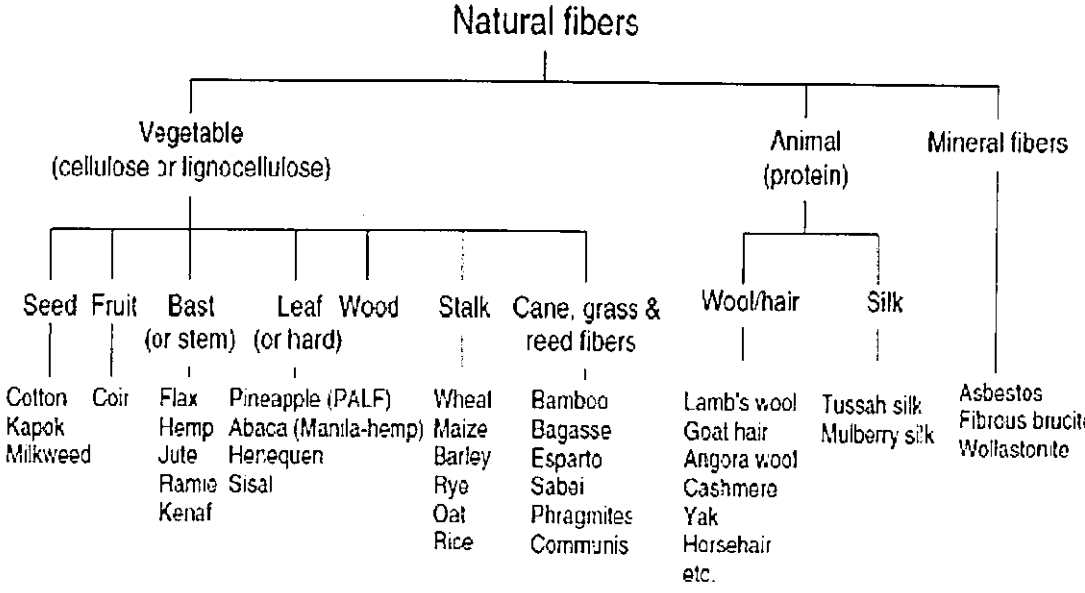

Figure 2.1: Groups of natural fibres (Leão et al., 2014)

Contrasted with synthetic fibres, common natural fibres bring a large number of points of interest for example, low cost, low density, fewer equipment abrasion, and respiratory irritation, improved energy recovery and biodegradability(Sgriccia, Hawley and Misra, 2008). Basically, natural fibres have high moisture and weak adhesion to hydrophobic matrices. The addition of hydrophilic in natural plant will create weak mechanical properties because of the non-uniform fibre dispersion in matrix. The way to improve the adhesion to matrix material is natural fibres need to be treated. Other than that, low degradation temperature of natural fibre makes them inharmonious with thermoset that have large curing temperature. There have other disadvantages of natural fibre such as large variability of mechanical properties, lower elongation, poor resistance to weather and lower ultimate strength.

The structure of the natural fibre consists of the hemicelluloses, lignin, cellulose, waxy and pectin substances. Weak bindings between the fibres and polymer because of the moisture absorption from the surrounding. The modification of natural fibres can change the composition and fibres structures by utilize of the reagent functional group. As a result, the moisture absorption of the natural fibre has been reduced which bring to the great improvement incompatibility between fibre and polymer matrix.

Natural fibres treatment was important factor to measured when processing natural fibres (Mohammed *et al.*, 2015). By performing different type of chemical treatment, natural fibres will lose hydroxyl group, thus reducing the hydrophilic behaviour of the fibres and causing improvement in mechanical strength and dimensional stability of natural fibres reinforced polymer composites. As the result, chemical treatment can enhancement of the natural fibres reinforced composites.

2.2 Pineapple plant

The pineapple is a tropical plant with a comestible multiple fruit consisting of coalesced berries. The pineapple plant in the family Bromeliaceous, subclass monocotyledons and species Ananas comosus. The word Ananas comosus is coming from Tupi word of 'nanas', means excellence fruit. All the world's pineapple cultivars are grouped in several classes which is Smooth Cayenne, Red Spanish, Queen and Abacaxi. The shape of the fruit look like pinecone make the plant is called "pineapple".

Brazil, Costa Rica, and China accounted as one of the world's production of pineapples, producing over 700,000 tone of fruit(Leão *et al.*, 2014). In India, it is refined on about 2250 000 acres of land and is continuously increasing its production. One of the top 3 largest country that produce pineapple in 60 and early 70 in Malaysia. Unfortunately, almost half of the 12 thousand hectares farm of the pineapple plant in Malaysia has been reduced. In Malaysia, the plant of the pineapple is unique because 90% plants in the peat soil which is considered marginal for most other agriculture crop(Y.K.Chan, 2000).People in Malaysia usually known pineapple as Nanas. Pineapple has been used in different varieties for different purpose which is red pineapple and green pineapple used for commercial purpose and Sarawak and Morris pineapple for edible purpose. Figure 2.2 show the red pineapple from Malaysia.

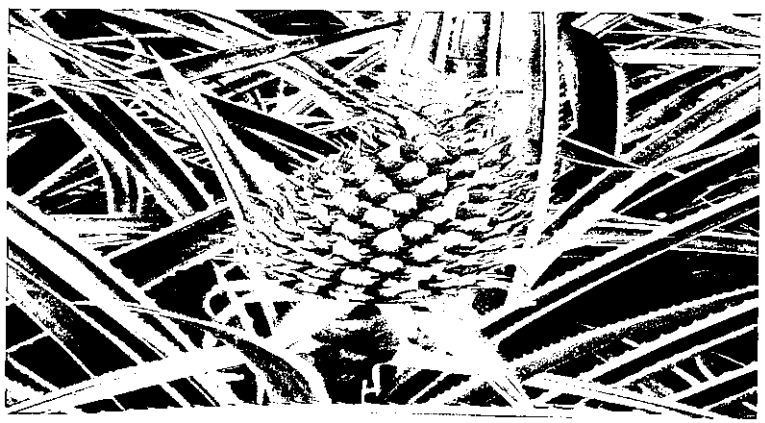

Figure 2.2: Red pineapple

Pineapple is ironic source of bromelain and other cysteine proteases are present in different part of pineapple. Many food industries, cosmetics, and dietary supplements usage bromelain from pineapple but some users need to evade from taking bromelain such as pregnancy, allergies or anticoagulation. The sore mouth feeling after eating pineapple due to the bromelain content of raw pineapple because enzymes react with the proteins.

New fruit will still growth continues through its base even after harvest. 200 days or 6-9 months on average the time need by the plant to allow fruit and propagated vegetative by cutting grown from the plant itself. The pineapple is a short and thick stem where the leaves grow in narrow, rigid and axillary roots. The plant can be categorizing as mature plant when the height of the plant reaches 1 to 1.2 meters, 0.80 width to 1.5 meters and can hold 80 leaves in every shape, with length of up to 1.3 meter. Old leaves place at base of the stem and younger leaves are elongated, conversing a wider baseline. Pineapple plant with detailed view of the leaf shown in figure 2.3.

Figure 2.3: Pineapple plant

2.3 Pineapple leaf fibres

Pineapple, banana and citrus is one of the significant tropical fruit in the world. Three type of species locally grown-up in Malaysia which is Moris Gajah, Smooth Cayenne and Josephine. Josephine is one of the suitable species for PALF extraction in term of the fibre quantity, fibre fineness, easy to extraction, mechanical and thermal properties(Fadzullah and Mustafa, 2016). However, the main centre of the plantation of pineapple industry in our country is just on the fruit and other corresponding foodstuff. The leaf normally become wasted in many countries. The pineapple leaf can be evaluated for industrial application to reduce the amount of waste that can harm the environment cause the environmental pollution. This pollution occurs because only fruit will be utilized, and the leaf will become wasted and burn by the farmer will be led to the release of the carbon dioxide.

To solve this problem, multiple researches and studies has been conducted related to the possibility of finding other applications to these pineapple leaf(Mohammed *et al.*, 2015). This will change the pineapple leaves from waste into wealth and save the environment from the pollution. There are several researches has been done by researcher on several aspect of PALF to studies the properties of PALF including physical, mechanical, and chemical.

Most of the previous researcher only focusing on PALF physical and mechanical properties. Chemical treatment of PALF will improve their fitness, resulted in degradation of their tensile properties. Chemical treatment can be done by using silane, acids or alkaline. The mechanical properties of the PALF is outstanding compared with other natural fibres associated with their high cellulose content and low microfibril angle(Leão *et al.*, 2014).

Pineapple leaves comes in shaped like a sword which ascend from a stem with an overall dimension from between 0.9 m to 1.5 m in length, while the width between 2.54 m and 5.1 m respectively. According to the research(Mohamed *et al.*, 2009), PALF have

highest tensile strength and middle elongation at break compared with the betel fruits and barks. The extracted of the PALF will deliver advantage in manufacture of yarn, woven fabrics, woven knitted, and handmade products(Leão *et al.*, 2014).

The mechanical properties of PALF can improve by perform surface treatment and PALF can replacing synthetic fibres in many applications. Natural fibres can transformed into nanocellulose, all the defect can be removed and resulting in the fibres with high specific modulus(Leão *et al.*, 2014). PALF is extracted by retting process and classify as multi-cellular and lignocelluloses. The colour of the leaves could be purely green or with a red spot, yellow and ivory(Fadzullah and Mustafa, 2016).

IBRAHIM, (2013) investigates the growth of PALF reinforced polymer composites in term of mechanical properties. The type of matrices has been used in this investigation is the thermosets and thermoplastic resins. The research proposed the major study can focus on long PALF that can be used in manufacturing such as vacuum bag moulding and autoclave moulding.

2.3.1 Extraction method of PALF

There have two method to extracted leaf fibres either manually or mechanically. In Philippines, they manually scraped by using a piece of broken porcelain or a small knife throughout the leaf. Figure 2.4 shown the manual process that started with scraping, beating, and husking the leaves. After that, fibres are soaked in water and added of chemical to improve the activity of the microorganisms.