EFFECT OF SURFACE TREATMENT ON PINEAPPLE LEAF FIBRE (PALF) AND ITS COMPOSITE

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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I hereby, declared this report entitled "Effect of surface treatment on the pineapple leaf fibre and its composite" is the result of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Engineering Materials) (Hons). The member of the supervisory committee are as follow:

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(Dr. ZALEHA BINTI MUSTAFA)

ABSTRAK

Tujuan kajian ini adalah untuk menilai kesan rawatan permukaan pada serat daun nanas (PALF) dan kompositnya. PALF dirawat menggunakan tiga keadaan yang berbeza iaitu alkali, salin dan gabungan alkali dan salin. Rawatan alkali dijalankan dengan dua masa perendaman yang berbeza iaitu pada 1 jam dan 3 jam pada kepekatan 3, 5, 6 dan 9 (w / v.%). Sementara, rawatan salin dilakukan pada 1, 2 dan 5 w / v% pada 3 jam waktu perendaman. Perubahan fizikal, kimia, mekanikal dan morfologi PALF yang tidak dirawat dan dirawat dianalisis dengan pengukuran ketumpatan Fourier Transform Spektrometri Inframerah (FTIR), Pengimbasan Mikroskop Elektron (SEM) dan ujian tegangan serat tunggal. FTIR telah mengesahkan bahawa rawatan alkali dan salin menghilangkan bendasing, lignin dan hemiselulosa. Ujian spectra FTIR mengesahkan kehadiran ejen gandingan organo-salin pada garisan gelombnag 893cm^{-1}. Alkali yang dirawat PALF mempunyai nilai ketumpatan tertinggi. Hasil dari ujian serat tunggal digunakan dalam analisis Weibull untuk meramalkan kegagalan kekuatan PALF. Weibull terhadap kekuatan tegangan (σ_o) menunjukkan rawatan alkali rawatan optimum berada pada 5 w.v% selama 1 jam (σ_o = 383.78 MPa) dan 5 w / v. % tumpuan saline (σ_o = 400.42MPa). Gabungan rawatan alkali dan saline meningkatkan kekuatan mereka dengan σ_o = hingga 492.95 MPa. Rawatan serat meningkatkan kekuatan komposit PALF / PLA dari 29.64 MPa kepada 40.80 MPa dan 40.46 seterusnya. Walau bagaimanapun, ia menyedari bahawa kombinasi alkali dan saline mengurangkan kekuatannya kepada 29.12MPa, kebarangkalian kerana kerosakan serat yang disebabkan oleh keadaan asid dalam rawatan salin. Kegagalan komposit disebabkan oleh patah serat dengan beberapa matriks yang jelas ke permukaan gentian yang menunjukkan ikatan yang baik antara antara muka matriks / serat akibat rawatan permukaan. Gabungan rawatan alkali dan salin telah mengurangkan kekuatan tegangan, kemungkinan akibat kerosakan serat dari rawatan permukaan

ABSTRACT

The aim of this study is to evaluate the effect of the surface treatment on the pineapple leaf fibre (PALF) and its composite. PALF were treated using three different condition which is alkaline, saline and combination of alkaline and saline. Alkaline treatment were carried out with two different soaking time which at 1 hour and 3 hour at concentration of 3, 5, 6 and 9 (w/v. %). While, saline treatment was carried out at 1, 2 and 5 w/v % at 3 hour soaking time. The physical, chemical, mechanical and morphological changes of the untreated and treated PALF were analysed by density measuring, Fourier Transform Infrared Spectrometry (FTIR), Scanning Electron Microscopy (SEM) and single fibre testing. The FTIR spectra confirmed that alkaline treatment removed lignin and hemicellulose. The FTIR confirmed that coupling of treatment indicated the present of organosaline agent at the wavelength 893cm^{-1}. Alkaline treated PALF has highest the value of density. The Weibull analysis of the tensile strength (σ_o) indicated the optimum treatment alkaline treatment is at 5 wt. % for 1 hours ($\sigma_{o =}$ 383.78 MPa) and 5 w/v. % saline concentration ($\sigma_{o =}$ 400.42MPa). The combination of alkaline and saline treatment improve their strength with $\sigma_{o =}$ to 492.95 MPa. The fibre treatment improve the strength of the PALF/PLA composite from 29.64 MPa to to 40.80 MPa and 40.46 MPa subsequently. However it was notice that combination the alkaline and saline reduced their strength to 29.12, probability due to damage of the fibre resulting from acidic condition in saline treatment. The composite failed due to the fibre fracture with some evident of matrix onto the fibre surface suggesting good bonding between the matrix/ fibre interface due to surface treatment. Combination of alkaline and saline treatment has significantly reduce the tensile strength, possibility due to damage of the fibre from the surface treatment.

DEDICATION

Only

my beloved father, Razid bin Yusof

my appreciated mother, Rosemawati binti Abd Rahman

my sister and brother , Sephia and Shukri

for giving me moral support, money, cooperation, encourage and also understanding

Thank You So Much & Love You All

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Material
FTIR	-	Fourier Transforms Infrared Spectroscopy
NaOH	-	Sodium Hydroxide
NF	-	Natural Fibre
NFPC	-	Natural Fibre Reinforced Composite
PALF	-	Pineapple Leaf Fibre
PLA	-	Poly (Lactic) acid
RT	-	Room Temperature
SEM	-	Scanning Microscopy
UV	-	Ultraviolet

LIST OF SYMBOLS

wt.%	-	Weight Percentage
w/v	-	Mass/Volume
µm	-	Micrometre
MPa	-	Mega Pascal
GPa	-	Giga Pascal
°C	-	Degree Celcius
σ_o	-	Tensile Stregth
β	-	Weibull Modulus
ρ	-	Density
cm	-	Centimetre
m	-	Metre
%	-	Percent
g/cm^3	-	Grams per centimetre cube
mm	-	Millimetre

CHAPTER 1

INTRODUCTION

1.1 Background

Over the last decade, composite of polymers reinforced with natural fibre (NF) have received increasing attention either from academic world or industries. The specific properties, price, and recyclability of NF are mainly attractive for industry. Composite based on polymer are widely used in various application. However, these type of composites hard to sustain biodegradation and led to serious problem in waste management. The landfill of the solid waste brings unbearable stress to environment (Benyahia *et al.* 2014).

Malaysia is one of the main producers of the pineapple in Asia. Pineapple leave fibres (PALF) normally will be end up as waste after harvesting. In 2008, the PALF is amounted to more than 384 thousands metric tonnes end up in landfill (Asim *et al.* 2015) which later may pose threat to the environment. From the socioeconomic, the PALF have a potential to be used as a new source of renewable reinforcement materials in composite industries, an alternative to the expensive and non-renewable synthetic fibres (Lee *et al.* 2010; Bahra *et al*. 2017).

Natural fibre such as PALF has potential to be use together with degradable matrix such as poly lactic acid (PLA) for fully biodegradable composite for landfill. PALF has high specific strength and stiffness. It is hydrophilic in nature due to high cellulose content. PALF consists of many chemicals elements. It is multicellular lignocellulose fibre containing polysaccharides, lignin in major quantity, and a few labourer chemicals like fat, wax, pectin, colour pigment, inorganic substance, and so forth (Ghosh *et al*. 1982)

However, the main drawback of the natural fibre is their low compatibility and poor interfacial adhesion with more hydrophobic polymeric matrix such as poly (lactic) acid with may lead to inefficient stress transfer and reduce their strength. Thus, many researched showed that surface treatment such as alkaline treatment, coupling agent may improve the interfacial strength (Valadez *et al.* 1999; Benyahia *et al.* 2014;). However, the chemical used in this treatment may alter reduce the intrinsic properties of the natural fibre itself. Orue (2016) reported that the usage of the medium acid in saline treatment could be the reason of the lower mechanical properties due to catalyse the cleavage of β-1, 4-glycosidic bonds between two anhydroglucose units and cellulose chain

However, a thorough study of the effect of surface treatment in PALF has been carried out yet. Thus this study will properly observe to find the balance between the surface treatment condition and maintaining the intrinsic properties of the natural fibre.

1.2 Problem Statement

PALF is one of the abundantly available waste materials in Malaysia and has not properly studied yet. The abundance of the PALF waste from the agricultural sector, mostly thrown to the landfill may pose threat to the waste management. PALF is fully degradable reinforcement materials can be utilised as in composite industries, which has advantage as they are not only from renewable sources but also environmental friendly. However, like many other natural fibre usage in the composite industries, it required further surface treatment to improve their fibre/matrix interfacial bonding in order to enhance their mechanical properties. While many study has been carried on the effect of the surface treatment in the natural fibre, few studies focus on PALF. Surface treatment such as usage of alkaline solution and acidic medium may alter the intrinsic value of the PALF. Thus a proper balance of the surface treatment condition is require to ensure high strength composite can be obtained.

1.3 Objective

The objectives are as follows:

(a) To compare the effect of the surface treatments on the physical, chemical and mechanical properties of pineapple fibre.

(b) The evaluate the effect of the surface treatment on the mechanical properties of the PALF/PLA composite

(c) To evaluate the morphological properties of the PALF and PALF/PLA composite

1.4 Scope

The scope of this study was to investigate the effect of surface treatments of pineapple leaf fibres onto their composite.

In objective I, the scope involves chemical treatment which is alkaline treatment (NaoH at 3, 5, 6 and 9 wt. % w/v) and couple agent treatment (saline at 1, 2 and 5 wt. % w/v). The effect of the treatment is characterized using density, FTIR and tensile testing

In objective II, the scope involves fabrication of the PALF bundle in PLA matrix using the optimized surface treated fibres. Their property is characterized via tensile testing.

In objective III, the surface quality of the chemical treated PALF and PALF/PLA composite is evaluated via SEM.

CHAPTER 2

LITERATURE

2.1 Introduction

This chapter provides an overview of previous research on knowledge sharing and intranets. This section introduces the framework for the case study that comprises the main focus of the research described in this thesis. The main content of this section is on pineapple leaf fibres (PALF) and poly (lactic) acid (PLA) which the main material used in this research. Also, included in this chapter is the discussion on the advantages, limitations and challenges in establishing the composites. Furthermore, the mechanical performance of several types of natural fibres reinforced composites from the past and recent study are also presented in this chapter.

2.3 Natural Fibre Reinforced Composites (NFPC)

Natural fibre polymer composites (NFPC) are a composite material consisting of a polymer matrix embedded with high-strength natural fibres (Mohammed *et al.* 2015). In general, depending upon the nature of the constituents, bio-based composites can be classified either as partly eco-friendly or green (Figure 2.1). Green composite implies that all its constituents are obtained from renewable resources, potentially reducing the carbon dioxide emissions and the dependence on petroleum-derived materials. While partly eco-friendly means that one of the constituents, either fibre or matrix, is not obtained from renewable resources (Mitra, 2014).

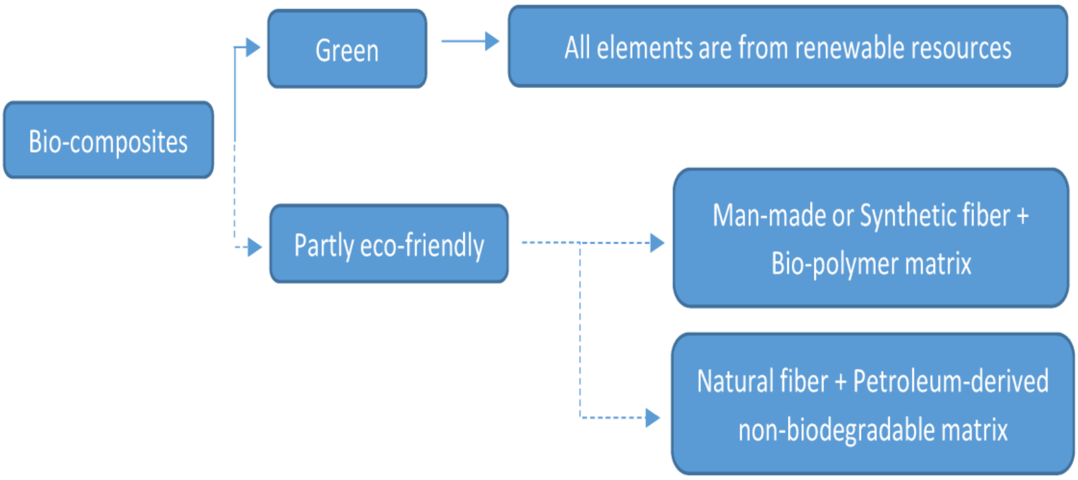


Figure 2.1 Classification of bio-composites
(Mitra, 2014; Mohanty *et al.* 2005; Dicker *et al.*2005)

2.3 Natural Fibre

It was believed that source of petroleum based products were limited and uncertain. So an alternative with cheap sustainable and easily available raw material is required. The countries growing plant and fruit are not for only agricultural purpose but also to generate raw materials for industries. Most of the developing countries trade lignocellulose fibres for improving economic condition of poor farmers as much as country support. Recently polymer composites containing cellulosic fibres are under focus in literature as well as industries(Asim *et al.* 2015).

Fuqua *et al.* (2012) stated that industry getting more interested on the natural fibre for the specific properties, price, health advantage and recyclability. Some of benefit link to the usage of natural composite are their low density and good specific properties. Furthermore, they are renewable and have neutral life cycle, reflected with the synthetic fibre. Basically, natural fibres are classification into three categories as shown in Figure 2.2

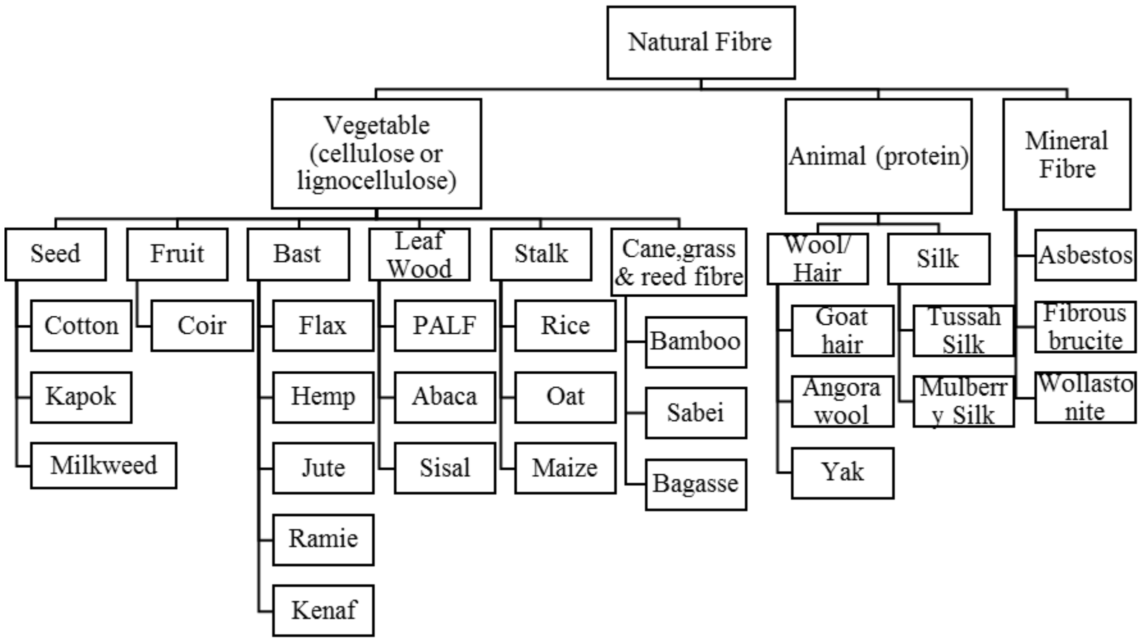


Figure 2.2 Classification Natural Fibers
(Source: Fuqua *et al*. 2012)

Natural fibre is a composite of the three polymers (cellulose, hemicelluloses and lignin), in which the unidirectional cellulose micro fibrils constitute the reinforcing elements in the matrix blend of hemicellulose and lignin. The structure of such a fibre was built as multiply construction with layers P, S1, S2 and S3 of cellulose micro fibrils at different angles to the fibre axis as shown in Figure 2.3.

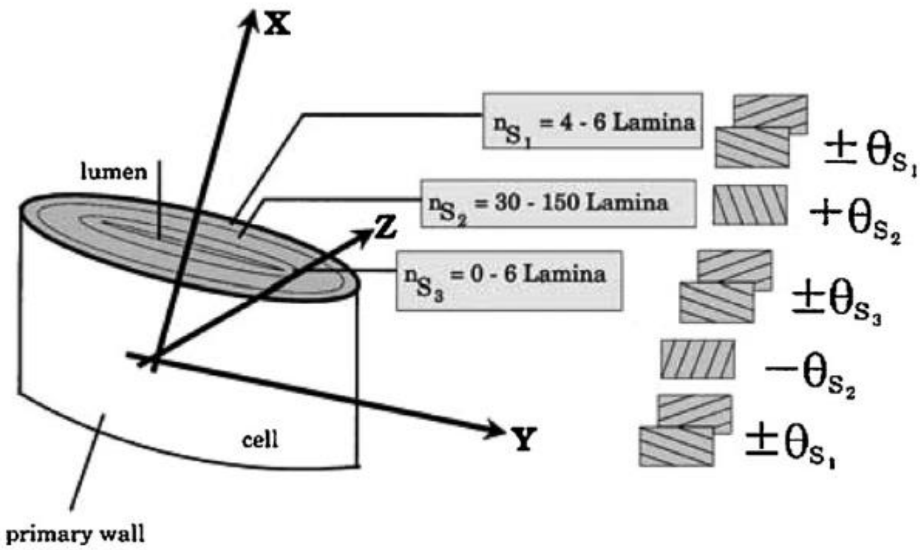
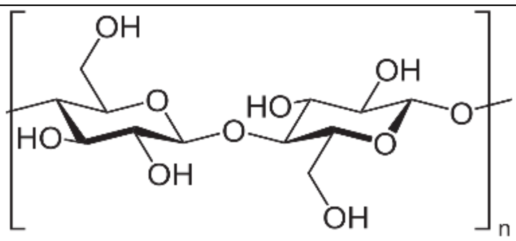
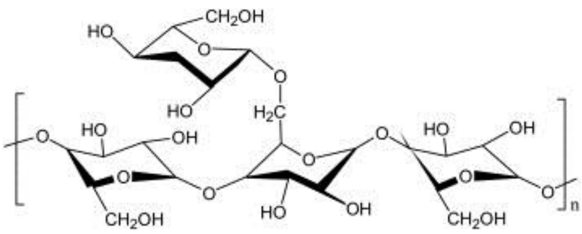
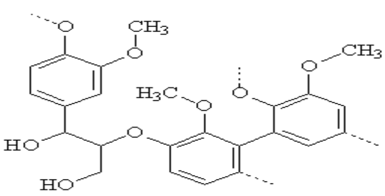


Figure 2.3 Illustration of a single fiber cell
(Faruk *et al.* 2012)

Saheb and Jog (1999) claimed that, chemical composition of natural fibres varies depending upon the type of fibre. Primarily, fibres contain cellulose, hemicellulose, pectin, and lignin. The properties of each constituent contribute to the overall properties of the fibre. Hemicellulose is responsible for the biodegradation, moisture absorption, and thermal degradation of the fibre as it shows least resistance whereas lignin is thermally stable but is responsible for the UV degradation. The percentage composition of each of these components varies for different fibres. Generally, the fibres contain 60–80% cellulose, 5–20% lignin, and up to 20% moisture. The molecular of fibre contain as shown in Table 2.1.

Table 2.1 Molecular structure of fibres contain.
(Fuqua *et al*. 2012)

Fibre content	Molecular structure
Cellulose	
Hemicellulose	
Lignin	

2.4 Pineapple leaf fibre (PALF)

Tran (2006) stated that, the pineapple is a perennial plant with a height of 75–150 cm, a spread of 90–120 cm, a short, stout stump, and a rosette of long (50–180 cm), narrow, fibrous and spiny leaves. A pineapple plant with a detailed view of the leaves is shown as Figure 2.4. PALF fibres are lignocellulose and multicellular (Reddy et al 2018)

Figure 2.4 Pineapple mature plant
(Leão *et al.*2014)

2.4.1 Extraction of PALF

PALF can be extracted either manually or mechanically. Traditionally need the mix of superimposed fibres in water which concerning 18 days to become saturated before the fibres are scraped manually. Then, fibres was clean and dry naturally. The extraction method of this sort of fibres is of great importance to the quality further as the yield of the fibres. In Philippines the fibre extraction of pineapple leaf is undertaken traditionally with proficient method by scraping a tiny low knife or a piece of broken porcelain throughout the leaf a conscientious (Leao *et al*. 2014)

The extraction process begins with the leaves through beating, scrape and husk as shown in Figure 2.5. Fibres are soaked in water after this shred process and chemicals can be mix to accelerate microorganism's activity that digest impurity materials and isolated the fibres., the huge wetting time is reduced using this process which from five days to 26 hours only. The wetting material then is washed and cleaned, dried naturally under the sun.

Meanwhile for mechanical process is carried out in a decorticator machine with the same principles of sisal fibre extraction (Leao *et al*. 2014)

Figure 2.5 Manual shredding of PALF
(Leao *et al*. 2014)

2.4.2 Structure and Chemical Composition of PALF

Attractive mechanical properties of PALF come from the high cellulose content and low micro-fibril angle that give them high mechanical properties of PALF. Variation of fibre properties depend on type of leaves, their dimensional appearance, length and thickness or diameter, planting conditions, age, and etc. (Fuqua *et al.* 2012). Table 2.2 shown the chemical composition of the PALF.

Table 2.2 Chemical composition of PALF (Taj and Munawar, 2014).

Cellulose (wt. %)	70-82
Lignin (wt. %)	5-12.7
Moisture Content (wt. %)	11.8
Microfibrillar (wt. %)	14