A STUDY ON THE EFFECT OF PHYSICAL, MECHANICAL AND, MORPHOLOGICAL PROPERTIES OF PINEAPPLE LEAF FIBER REINFORCE CORNSTARCH BIODEGRADABLE PLASTIC COMPOSITE

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DECLARATION

I declare that this thesis entitled “The Effect Of Pineapple Leaf Fiber Reinforce Cornstarch Biodegradable Plastic Composite To The Physical, Mechanical, And Morphological Properties” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Name :.....

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APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Bachelor of Mechanical Engineering.

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Name :.....

Date :.....

ABSTRACT

This research is focused on investigating the effect of fibre loading of PALF reinforced cornstarch biodegradable plastic composite to the physical and mechanical properties. Recently, a lot of research are performed related to the development of biodegradable material especially in green technology. Natural fibre has seen to be the most suitable substitute for replacing the synthetic fibre due to many advantages such as low cost, variety and redundant of sources and its bio-degradability properties. By selecting the PALF, it can help in creating a new eco-friendly polymer and reducing the percentage of PALF waste. The objective of this research is to investigate the effect of PALF fibre loading to the cornstarch reinforcement in term of physical, mechanical and morphological properties. During the research, fibre loading of 5 wt%, 10 wt%, 20 wt%, 30 wt%, 40 wt %, 60 wt % and 70 wt % has been used as the sample. The composites is being fabricated using the hot-press machine. Testing of the composite are divided into two phases. First phase consist of physical and mechanical testing while the second phases consists of morphological analysis. The result from the physical testing, the value each physical properties; density, water absorption and moisture content shows that these properties are affected by the percentage, wt%, of PALF fibre loading. The mechanical testing result shows that PALF with 30 wt% has the highest reading for both tensile and flexural strength. For morphological analysis, composite sample of 30 wt% PALF fibre loading did not has gap between matrix and fibre .For this research, it can conclude that, 30 wt% of fibre loading is the most optimum fibre loading for 3cm length PALF compared to other composition ratio. Further study on characteristic of cornstarch as matrix is recommended in order to analyse the reaction of the matrix and fibres.

ABSTRAK

Penyelidikan ini memfokuskan kepada penyiasatan terhadap kesan kandungan serat komposit serat daun nenas yang diperkuatkan dengan tepung jagung dibiodegradasi terhadap sifat fizikal dan mekanikal. Sedekad kebelakangan ini, banyak penyelidikan yang berkaitan dengan perkembangan bahan boleh dibiodegredasi terutamanya dalam bidang teknologi hijau. Serat semula jadi adalah yang paling sesuai untuk mengantikan serat sintetik kerana mempunyai banyak kelebihan seperti pengurangan kos, sumber yang banyak dan pelbagai serta kebolehan biodegredasi. Dengan memilih serat daun nenas, ia dapat membantu untuk menghasilkan polimer mesra alam yang baru dan mengurangkan peratusan pembaziran daun nenas.Objektif untuk penyelidikan ini adalah untukmenyiasat kesan kandungan serat daun nenas terhadap bahan pengukuh dalam terma sifat fizikal dan mekanikal serta analisis morfologi. Semasa penyelidikan, 5 wt%, 10 wt%, 20 wt%, 30 wt%, 40 wt %, 60 wt % dan 70 wt % kandungan serat telah digunakan sebagai sampel. Bahan composite dihasil menggunakan mesin tekanan panas. Pengujian sampel terbahagi kepada dua fasa. Fasa pertama ialah pengujian terhadap sifat fizikal dan mekanikal dan fasa kedua ialah analisis morfologi. Keputusan daripada pengujian sifat fizikal, data menunjukkan bahawa sifat ketumpatan, kandungan kelembapan serata keserapan air terhadap bahan komposit dipengaruhi oleh peratusan, wt%, kandungan serat. Pengujian sifat mekanikal menunjukkan bahawa kandungan serat daun nenas sebanyak 30 wt% memiliki nilai kekuatan tegangan yang paling tinggi begitu juga dengan keputusan untuk ujian kekuatan lenturan. Untuk analisis morfologi, kandungan serats 30 wt% tidak menpunyai kecacatan yang dominan antara serat dan matriks. Dapat disimpulkan bahawa, untuk penyelidikan ini, kandungan serat sebanyak 30 wt% adalah yang paling optimum untuk serat daun nenas sepanjang 3 sentimeter. Penyelidikan mendalam terhadap sifat tepung jagung sebagai matrik direkomendasikan.

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Abbreviations

PALF	Pineapple Leaf Fibre
PFRR	Polymer From Renewable Resources
PLA	Polyactic acid
PHB	Polyhydroxy Butyrate
SEM	Scanning Electron Microscopy
CFRP	Carbon Fibre Reinforced Polymer
NFRP	Natural Fibre Reinforced Polymer
GFRP	Glass Fibre Reinforced Polymer
TPS	Thermoplastic Starch
RH	Relative Humidity
UTS	Ultimate Tensile Strength

LIST OF SYMBOL

Symbol	
NAOH	Sodium Hydroxide
OH	Hydroxyl
NA	Sodium
H_2O	Water
ρ	Density
m	Mass
V	Volume

CHAPTER 1

INTRODUCTION

1.0 Overview

Lately, the world has been facing so many problems regarding to environmental issues. Some of the issues arise are such as the harmful industrial material that can affected people health, the disposal of the unbiodegradable material such as plastic and the global warming cause by the greenhouse effect. In order to overcome these arising problem, researchers from all over the world are considering in producing environment-friendly material or also known as green material. One of the solution that recently highlighted by the researchers is that replacing the synthetic fibre composites with the natural fibre composites. This is due to the reason that natural fibre has many advantages compared to the synthetic fibre. The advantages of the natural fibre are (Pickering, Afendy and Le, 2016) low in density and high specific strength and stiffness, renewable resource, can be produced at lower cost than synthetic fibre, low hazard manufacturing processes, low emission of toxic fumes when dealing with heat and during incineration at end of life, and less abrasive damage to processing equipment compared with that for synthetic fibre composites. There are many bio-composites products that are being commercialized from a fibre based plant such as kenaf, jute, roselle, sugar palm fibre and banana pseudo stems.

The pineapple leaf fibre (PALF) is one of the natural fibre that potentially to be used as the reinforcing materials in green composite product as it is very marketable in

Malaysia due to the facts that it is one of the most important tropical fruits in Malaysia. This is due to the fact that in Malaysia alone, over 130 distinct species of pineapple are cultivated. Currently, the main focus of this country pineapple industry are the fruits and related foodstuffs while the pineapple leaves are treated as agricultural wastes where it either being let composted or burned by farmers. This lead to the wasting of a very potential source of good natural fibres.

Researchers found that the PALF are vary in their properties according to the plant types, geographical regions, plant age, and weather conditions. Non-treated and treated PALF of various lengths and fibre loadings have been used to reinforce matrices such as polypropylene, polyethylene, polycarbonate and polyester (Mohamed *et al.*, 2009).

Polymers from renewable resources have attracted the attentions of researcher because of two major reasons that is firstly environmental concerns, and secondly the realization about the finite of petroleum resources. Polymers from renewable resources (PFRR) can be classified into three groups where the first group is natural polymers, such as starch, protein and cellulose synthetic polymers, while the second group is from the natural monomers, such as polylactic acid (PLA) and lastly the polymers from microbial fermentation, such as polyhydroxy butyrate (PHB). Many properties of PFRR can also be improved through blending and composite formation like numerous other petroleum-based polymers. In order to prevent premature degradation, it is important to control the environment in which the polymers are used. For instance, the water solubility of majority of natural polymers raises their degradability and the speed of degradation, but this moisture sensitivity will limit their application.

A new direction of developing the biodegradable polymers from renewable resources is provided by the development of synthetic polymers using monomers from

natural resource. One of the most promising polymers in this matter is PLA, since it is made from agricultural products and readily biodegradable (Yu, Dean and Li, 2006).

This study discusses the PALF's mechanical, chemical, thermal, and physical characteristic comparing it with the other established bast fibres like kenaf and roselle. In this research, the PALF was treated using alkali treatment in hopeful to produce a PALF composites that have better physical, mechanical, morphological and thermal properties. The mechanical properties and reaction of the PALF and natural polymer or in this content corn-starch will be observed and valued in this study and hopefully to produce a fully functioning composite that are 100% consist of natural material.

1.1 Problem Statement

Natural fibres are being the main focus of research as it is more environmental friendly if compared to the existing glass and carbon fibres. Other than that, natural fibre has a lot of unexplored potential and advantages which attracted researcher all around the world to conduct the studies. Although natural fibre contains many advantages and potentials, it also has its own shortcomings. Results from previous studies show that natural fibre has a lower strength compared to the synthetic fibre like glass and carbon fibre. To overcome this problem, natural fibre need to be re-strengthen before it can be used as a composite.

The pineapple leaf fibre (PALF) can be abundantly found in Malaysia as it is one of the biggest sector in Malaysian agriculture sector. Generally, the leaves of the pineapple plant are let to composed or burnt as that only the fruits are being used. It is a waste as the leaves can be treated as one of the main resources of natural fibres for natural composites.

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1.2 Research Objectives

For this research, there are two objective that are:

1. To investigate the effect of PALF fibre loading to the cornstarch reinforcement in terms of physical and mechanical properties.

2. To evaluate the effect of PALF fibre loading to the cornstarch reinforcement in terms of morphological properties.

1.3 Scope of Study

The aim of this study is to evaluate the effect of fibre loading on the pineapple leaf fibre (PALF) reinforced corn starch polymer in terms of its morphological, mechanical and thermal properties. In this research, the PALF is treated with alkaline treatment and blended with corn starch and glycerol mixture to form the composite sample. The research's methodology is experimental investigation where it is divide into two phases.

The first phase of this research is to investigate the fibre loading of PALF toward physical and mechanical properties of the composites. The composites were prepared into four fibres loading which are, 5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%, 60% and 70%. The composites are being fabricated by laying up the PALF and corn starch with glycerol mixture into the mould and then will be inserted into the hot press machine. The testing involved in the phase are density test, moisture test, water absorption test, tensile testing, and flexural test.

The second phase involve the analysis of the morphological properties of the PALF reinforced corn starch polymer. The testing that being done is Scanning Electron Microscopy (SEM).

All of these testing is being done by following the standards involved according to each method.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

For the last two decade, researchers and scientist have been attracted to the study about polymer from renewable resources (PFRR) due to environmental concern and finite petroleum resources realization. These problems have made bio composite considerable important and becoming a very wide range of properties of engineering materials. The main advantages of natural polymer are that it has a good potential in management of waste, biodegradability and in lower ash production during the incineration.(Yu, Dean and Li, 2006)

These renewable resources of polymer come in three types that are polymers from natural resources, (starch, protein, cellulose), synthetic based polymer that consist of natural monomer (polylactic acid, PLA), and microbial fermentation based polymer such as polyhydroxy butyrate,(PHB).(Avérous, 2004)

2.1 Natural Fibre

Following the major issues that commonly criticized by the public that is serious environmental problems after disposal of advanced composites as it is hardly to be recycled, the structure from advanced composites may be over strength especially when the carbon fibre reinforced polymer composites (CFRP) are used, the relatively high cost of advanced composites for domestic products, and the petroleum crisis that has been arising for this few years has made researchers to focus on substitute material that able to

overcome these problem(Lau *et al.*, 2018). Some of the material that is being considered is the bio composite which are consist fully of natural material. The development in the rising of the bio based composites are impressive is view from a technical point which can be reflected through their rapid growth in the industrial market.(Faruk *et al.*, 2012) These shows that natural composites have a very high potential to be the perfect substitute of advanced composites.

Bio composites compositions majorly consist of natural fibres. Natural fibres can be classified into two types(Lau *et al.*, 2018) . The first type is the animal based**,** that are silk from cocoon, chicken's feather, wool and silk from spider. These types of fibre are commonly apply in biomedical applications such as implants as it is required to be either biodegradable and biocompatible to avoid harm to human body. The second type is the plant based**.** Jute, hemp, sisal, kenaf, coir, flax, bamboo and banana are example of this type. The plant type nature fibre is usually mixed with polymers to form natural fibre reinforced polymer (NFRP) composites. It can be categorized as renewable sources and can be extracted from the nature without damaging the environment. Can be the substitute of glass fibre as the composites NFRP's mechanical properties are equivalent to glass fibre reinforced polymer (GFRP)

For the plant based natural fibres sources, depending on the utilization, the fibres are divided into primary and secondary where the primary class are those plant which grown for their fibre. Example of primary plant are sisal, jute, kenaf and hemp. While the secondary type of plant is where the fibre is produce as a by-product. Example of secondary plant are pineapple, oil palm and coir.

To exhibit a hierarchical structure, the structure of plant fibres can be further explained through three main components shown in Figure 2.1 below: (Fadzullah and Mustafa, 2017)

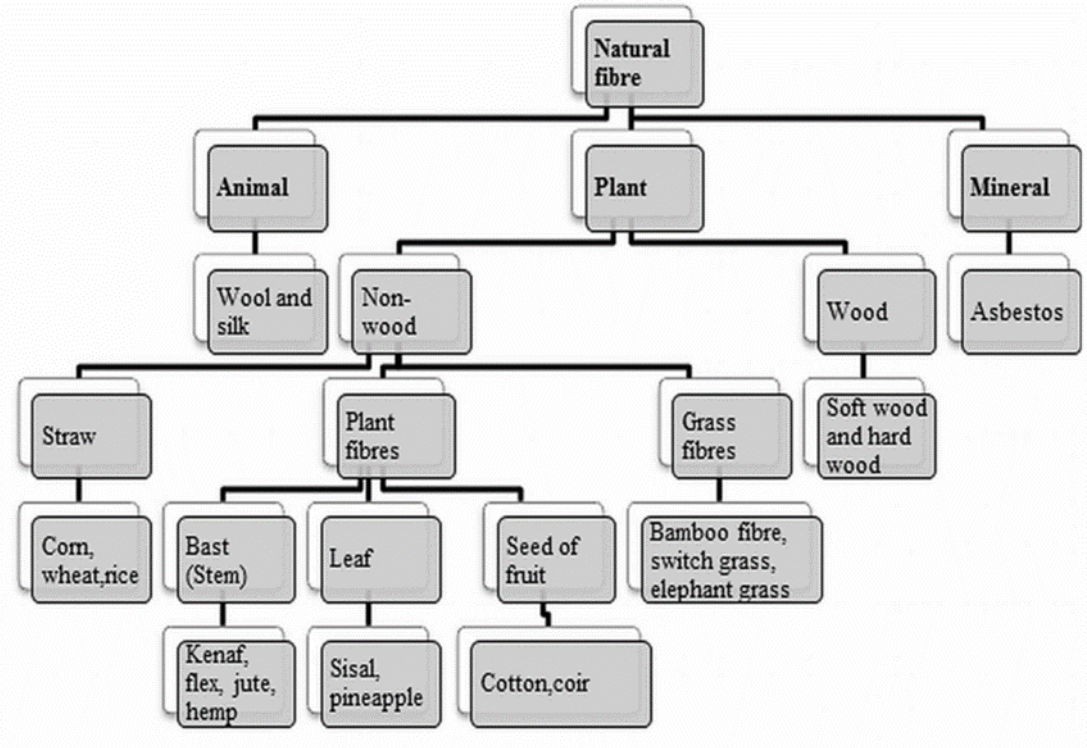

Figure 2.1: Natural Fibre Main Classes (Lau et al., 2018)

Natural fibre properties are varied. This is because the moisture conditions and testing method being used are depending on which type of fibre that are being used. Therefore, different fibre will give different moisture condition and different testing method will be employed. According to study done by researcher(Faruk *et al.*, 2012) the performance of natural fibre is depending on few factors which included the chemical composition of the fibre, dimensions of the cell , angle of microfibrillar, defects, structure, properties of physical, properties of mechanical and the interaction between fibre and polymer. Therefore, it is required to know the behaviour of natural fibre. The same characteristic of natural fibre reinforced polymer are also being listed out in other researcher study (Mohammed *et al.*, 2015). The range values of characteristic are remarkably higher than glass fibre, which is explained through the different of internal fibre structure due to the overall environment situation during the natural fibre growth.

Natural fibre structure includes a functional group known as hydroxyl group which contribute to the hydrophilic characteristic in natural fibre. Due to the present hydroxyl group, a weak interfacial bonding appeared between hydrophilic natural fibre and hydrophobic polymer matrices during the manufacturing process of NFRP. Not only that, the hydrophilic properties in natural fibre influences the natural fibre's mechanical properties especially for all the cellulose-fibre as the moisture content of fibres is dependent on the non-crystalline content and the fibre void content. Table 2.1 shows the equilibrium moisture content of some natural fibres:

Table 2.1:The Equilibrium Moisture Content Of Natural Fibres

Fiber	Equilibrium moisture content (%)
Sisal	11
Hemp	9.0
Jute	12
Flax	7
Abaca	15
Ramie	9
Pineapple	13
Coir	10
Bagasse	8.8
Bamboo	8.9

The internal structure of natural fibre is reliant on age and origin of the plants and climate conditions.(Lau *et al.*, 2018)

Natural fibre attracts the attention in many applications due to its satisfactory properties and greater benefit of nature fibre compared to synthetic fibre in terms of its low weight, require less cost, decrease damages to the equipment, good mechanical properties such as tensile strength and flexural strength, surface finish improvement of moulded parts composites, renewables sources, being abundant, flexibility processing, biodegradable and minimum health hazard.

However, like every other material, natural fibre also has its own downcast. Natural fibre structure comprises of cellulose, hemicellulose, lignin, pectin and waxy substance, allowing the absorption of moisture from the surrounding that has resulted to weak bindings between fibres and polymer.

To overcome the problems, modification using special treatment can be made towards the natural fibres. The special treatment generally focused on the utilisation of reagent functional groups that can respond to the fibre structure and changing their composition that will resulted to reduction of moisture absorption by leading to an excellent enhancement of the incapability between the fibres and matrices. The surface treatment main objective is to enhance the interfacial of fibre and matrix bonding and the transferability of the composites. The improvement in mechanical strength as well as the dimensional stability of NFRP can be achieved when the hydrophilic behaviour of the fibres is reduced when going through chemical treatment such as alkali treatment.(Mohammed *et al.*, 2015)