AN INVESTIGATION ON PHYSICAL, MECHANICAL AND MORPHOLOGICAL BEHAVIOUR OF CORN STARCH REINFORCED WITH ALKALINE TREATED PINEAPPLE LEAF FIBRE

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DECLARATION

I declare that this project entitled “Investigation on Physical, Mechanical and Morphological of Corn Starch Reinforced Alkaline Treated Pineapple Leaf Fibre” is the result of my own work except as cited in the references.

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Honours.

Signature : ....

Supervisor's Name : ....

Date :..

DEDICATION

To my beloved mother and father

ABSTRACT

Recently, natural fibre reinforce composite (NFPC) is knowingly as attentive source and have potential replacement over common synthetic fibres in several applications that commonly related to automotive and construction industry. The purpose of this study is to investigate the physical, mechanical and morphological behaviour of natural composite of corn starch reinforced alkaline treated pineapple leaf fibre. Composites can be defined as material with multifunctional system that have certain characteristic which cannot be found in other discrete material. Previously, pineapple plant is not fully utilised and has become as the agriculture waste until the researchers found that pineapple leaf can be turned into fibre that is beneficial to certain industries and applications. Due to rapid technology era and high knowledge people nowadays, pineapple leaf fibre has been used widely for composite production because the fibre own good mechanical properties and shows superior properties based on the high cellulose content and low microfibrillar angle (Kengkhetkit and Amornsakchai, 2012). Several steps have been done to evaluate the physical, mechanical and morphological behaviour of natural composite between pineapple leaf fibre and corn starch. Initially, pineapple leaf fibre and corn starch was prepared according to the certain fibre loading. Several tests were conducted on the samples to determine the physical properties such as moisture content, water absorption and density. Regarding to the results obtained, all of these physical properties is increase linearly with the increasing fibre loading wt%. Besides, mechanical properties such as tensile, flexural strength and hardness also determined by mechanical tests. The results show that tensile properties is optimum at 60 wt% while for the flexural strength is maximum at 40 wt% fibre loading. Based on this study, the physical and mechanical properties are depending on the fibre loading wt%. The characterization of the fracture tensile also figured out by conducting Scanning Electron Method (SEM). Work frame also provided as for better improvements in the future.

ABSTRAK

Sejak kebelakangan ini, komposit serat semulajadi diketahui umum sebagai sumber yang mendapat perhatian dan berpontensi menggantikan serat sintetik dalam beberapa aplikasi yang berkait rapat seperti dalam industri automotif dan pembinaan. Tujuan kajian ini adalah untuk mengetahui tentang sifat fizikal, mekanikal dan morfologi yang wujud pada komposit serat semulajadi yang melibatkan tepung jagung dan serat daun nenas yang telah dirawat dengan alkali. Komposit boleh didefinisikan sebagai bahan yang mempunyai pelbagai kegunaan dan sifat yang tiada pada material lain. Sebelum ini, daun nenas tidak digunakan dan menyebabkan ia menjadi bahan buangan dalam sector agrikultur sehingga pengkaji menyedari bahawa daun nenas boleh diekstrak menjadi serat yang bermanfaat untuk beberapa industri dan aplikasi. Dalam era pembangunan yang pesat dengan teknologi dan manusia yang berpengetahuan tinggi, serat daun nenas telah digunakan secara meluas untuk pembuatan komposit kerana serat daun nenas mempunyai sifat mekanikal yang bagus dari segi kandungan selulosa dan sudut mikrofibrila yang rendah (Kengkhetkit and Amornsakchai, 2012). Beberapa langkah telah dijalankan untuk mengkaji sifat fizikal, mekanikal dan morfologi yang ada dalam komposit semulajadi yang melibatkan tepung jagung dan serat daun nenas. Langkah awal telah dijalankan dengan menyediakan tepung jagung dan serat daun nenas kepada beberapa komposisi serat dari segi peratusan berat. Beberapa ujian juga telah dijalankan untuk mengetahui sifat fizikal yang terdiri daripada kandungan kelembapan, serapan air dan ketumpatan. Berdasarkan keputusan yang diperolehi, kesemua keputusan fizikal ini menunjukkan kenaikan yang sekata mengikut peratusan berat serat yang makin bertambah. Selain itu, sifat mekanikal seperti kekuatan tegangan, kekuatan lenturan dan kekerasan juga dikaji melalui ujian mekanikal. Keputusan menunjukkan kekuatan tegangan adalah optima pada 60 peratus berat serat, manakala kekuatan lenturan memberi nilai maksima pada 40 peratus berat serat. Berdasarkan keputusan yang diperoleh, sifat fizikal dan mekanikal komposit semulajadi ini adalah bergantung kepada peratusan berat serat daun nenas. Ujian morfologi juga dijalankan untuk mengetahui pencirian komposit pada permukaan yang terjejas setelah menjalani ujian tegangan. Rangka kerja untuk menaik taraf kajian pada masa akan datang juga telah disediakan.

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LIST OF ABBREVIATIONS

PALF	Pineapple Leaf Fibre
ASTM	American Society for Testing and Material
SEM	Scanning Electron Microscopy
NFPC	Natural Fibre Reinforced Polymer Composite
CMC	Ceramic Matrix Composite
PMC	Polymer Matrix Composite
MMC	Metal Matrix Composite
PP	Polypropylene
PE	Polyethylene
PS	Polystyrene
PVC	Polyvinyl chloride
TPS	Thermoplastic Starch
UTS	Ultimate Tensile Strength

LIST OF SYMBOLS

m	-	Mass
p	-	Density
V	-	Volume
A	-	Area
r	-	Radius
F	-	Force
wt%	-	Weight percentages
σ	-	Stress
NaOH	-	Sodium Hydroxide
OH^-	-	Hyroxide
H_2O	-	Water
Na^+	-	Sodium
CO_2	-	Carbon Dioxide
l	-	Length
w	-	Width
t	-	Thickness

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Natural fibres have been used since the dawn of civilization. For thousand years, natural fibres were used by the mankind as the essential things to insulate the bodies against warm and cold weather, protect the food from vermin and even decorate the environment. In addition, clothing, housing, and even baskets that used to store and carry food back then were made of natural fibre. The earliest evidence of human using fibres found that date back to 36000 BP when the discovery of wools and dyed flex in a prehistoric cave in the Republic of Georgia. Until the last hundred years or so, the only fibres used by mankind were natural fibre and the first man-made fibre that known as synthetic fibre was discovered in 1865.

Recently, natural fibre composites and synthetic fibre composites were commonly used in worldwide as they are useful for the high-tech applications such as composites part for automobiles, material industries, food product industries and etc. Although there are good development in using the synthetic fibre composites based product nowadays, there are lot of crucial environmental issues that can affect to our health, leads to global warming and disposal of plastic products in our world. One of the common issues is protecting the environment from using non disposable material. Many researchers have considered to spread the goodness of using natural fibre composites rather than synthetic fibre composites in industrial and our daily activities. Composites with natural fibres have advantages such as lower density, lower processing cost, good thermal insulation and reduce skin irritation compared to glass fibre composites. Nowadays, there are a lot of bio-composite products that have been commercialized form plant based fibres. Some examples of composites based on natural fibres include kenaf, jute, sugar palm fibres and banana pseudo stem.

The pineapple leaf fibre is one of the natural fibre which has great potential to be used in bio-composite engineering. Pineapple plant can be found abundantly in Malaysia even though the top pineapples producing countries are Costa Rica, Brazil, Philippines and Thailand. Pineapple plants have contributed development in socioeconomic in Malaysia as our country has the industries that produced canned pineapple, pineapple extracted juice and etc. Pineapple fruit has high demanding recently, but there is still lack of use of the plant because pineapple leafs normally become agriculture waste. Many researchers try to make value added for pineapple leafs and transform them from “trash” to “cash”. The fibre is extracted from pineapple leafs using extract machine in order to soften the fibre for easy handling. Pineapple leaf fibre have its own advantages such as it having highest cellulosic content nearly 80% and Young Modulus shows highest tensile strength when compared to other natural fibres (Mohammed *et al.*, 2015)

This study discusses the physical, mechanical and morphological behaviour between alkaline treated pineapple leaf fibre and corn starch. Besides that, the effect of fibre loading wt% of pineapple leaf will be discussed thoroughly. The effect of alkaline treatment and the specific length of pineapple leaf fibre is also taken into account

1.1 Problem Statement

Currently, studies on new combining composite materials focus on enhancing their mechanical and physical properties while reducing the production cost. Many researchers shown their effort in studies and producing the composite materials that are eco-friendly and sustainable to industries worldwide.

Commonly, petroleum and natural gas are raw materials for plastic manufacturing that contribute in many industries such as packaging, building and construction, aerospace and automotive. They are assumed to depletion within next 40-60 years that make the mankind think and give a lot of attention in renewable energy and sustainable industry. Natural composite abundant materials such as cellulose fibre have widely utilized as natural fibre reinforcement in a composite to partially replace the petroleum-based plastic material. As for the natural fibre composite that obtained from plant only require short time of growth before it is ready to harvest. The benefits are not only increases productivity of the product, but natural fibre also reduced cost, improves mechanical properties and composite weight reduction.

The natural fibre composite can be extracted from plant such as kenaf, jute and pineapple. This study will be focused on pineapple leaf fibre as it has good potential to replace current reinforced materials such as glass and carbon fibre that can be easily get. Pineapple is one of the popular fruit crop grown in Malaysia and the planting of pineapple is presently confined to the peat soil area commonly located in the state of Johor and in other states such as Kedah, Perak, Negeri Sembilan, Kelantan, Terengganu and Sarawak. The pineapple industry in Malaysia is the oldest agriculture based export oriented industry even though it is relatively small compared to palm oil and rubber. Nowadays, pineapple industry plays important role in the country's socioeconomic development because of the huge production every year. However, tons of pineapple leaf have become agricultural waste after harvesting that attracted the researcher to make use of it for value added in certain industries. Previous study proves that pineapple leaf fibres that have undergo extraction process called mechanical milling and the fibre knowingly consist of cellulose about 70-80 wt% with higher specific modulus and strength (Panyasart *et al.*, 2014). Hence, the pineapple leaf fibre seems to be suitable for making them as the products but there are still some improvement need to be done to enhance their properties.

These days, we can see many products that have been commercialized are made up from natural fibre composites. However, most of the product that made up from natural fiber composites that also known as biodegradable and good for environment are actually not fully natural. For instance, plastic bags, food packaging and automobile parts is made up from natural fibre composites but still using synthetic as the matrix. In this study, natural matrix that is corn starch will be used to blend with the pineapple fibre leaf. The advantages of using corn starch as the matrix are low cost and availability from agricultural crop. Starch based matrix, however are brittle and hydrophilic, therefore the processing and application using it is limited. In order to overcome these drawback, glycerol that is colourless, odourless and viscous will be added as the non-toxic plasticizer into the corn starch. These plasticizers function is to decrease the absorption of water in starch, which prevents the material from becoming brittle.

1.2 Research Objectives

The objectives of this study are stated as below:

1. To investigate the effect of fibre loading of the alkaline treated PALF reinforce corn starch composite to the physical and mechanical properties.
2. To evaluate the effect of fibre loading of the alkaline treated PALF reinforce corn starch to the morphological properties.

1.3 Scope of Study

The aim of this research is to accomplish a greater understanding about the pineapple leaf fibre's properties in terms of its mechanical behaviour, physical and morphological properties. The pineapple leaf fibre was treated using alkaline treatment in order to evaluate the effect of treatment to their properties. Finally, the fibre was lay up with natural matrix which is corn starch to form natural composites samples. The methodology in this research is experimental investigation. The research was classified into three different phases.

The first phase of the research is to evaluate the characterization of pineapple leaf fibre after undergo alkaline treatment. The pineapple leaf was collected randomly from Johor. The pineapple leaf fibre was extracted from the pineapple leaf using mechanical milling method. The extracted pineapple leaf fibre then treated with alkaline treatment and used as the research samples. This study does not cover the details on the pineapple plant and the biological effect of the plant in term of location and species. This study focuses on the characterization of physical (density, water absorption and moisture content), mechanical (tensile strength and flexural strength properties) and morphological behaviour. The results were then compared according to the different loading of pineapple leaf fibre.

The second phase of this research is to determine the mechanical behaviour of treated pineapple leaf fibre according to its specific length (1cm). After undergo alkaline treatment, the pineapple leaf fibre is scratched to soften and as to ensure them will be mixed perfectly with the matrix/binder in the next stage. The pineapple leaf fibre then cut into short length (1 cm).

The treated short pineapple leaf fibre then lay up together with the natural matrix/binder which is corn starch. Due to the brittleness of corn starch as the matrix, corn starch was mixed with the non-toxic plasticizer that is glycerol. In this stage, several sample with the different ratio between pineapple leaf fibre and corn starch have been made. The aspect of ratio between pineapple leaf fibre and corn starch are the crucial part in this research as to determine their mechanical, physical and morphological properties. Tensile and flexural test were conducted to investigate the mechanical behaviour of pineapple leaf fibre. A Scanning Electron Microscopy (SEM) analysis was conducted to evaluate the morphological properties. The results of this natural composite samples were compared according to the pineapple leaf fibre loading as to obtain the optimum result in mechanical properties.

1.4 Gantt Chart For PSM I & PSM II

Figure 1.1 and Figure 1.2 show the Gantt chart which included the activities performed for PSM I and PSM II.

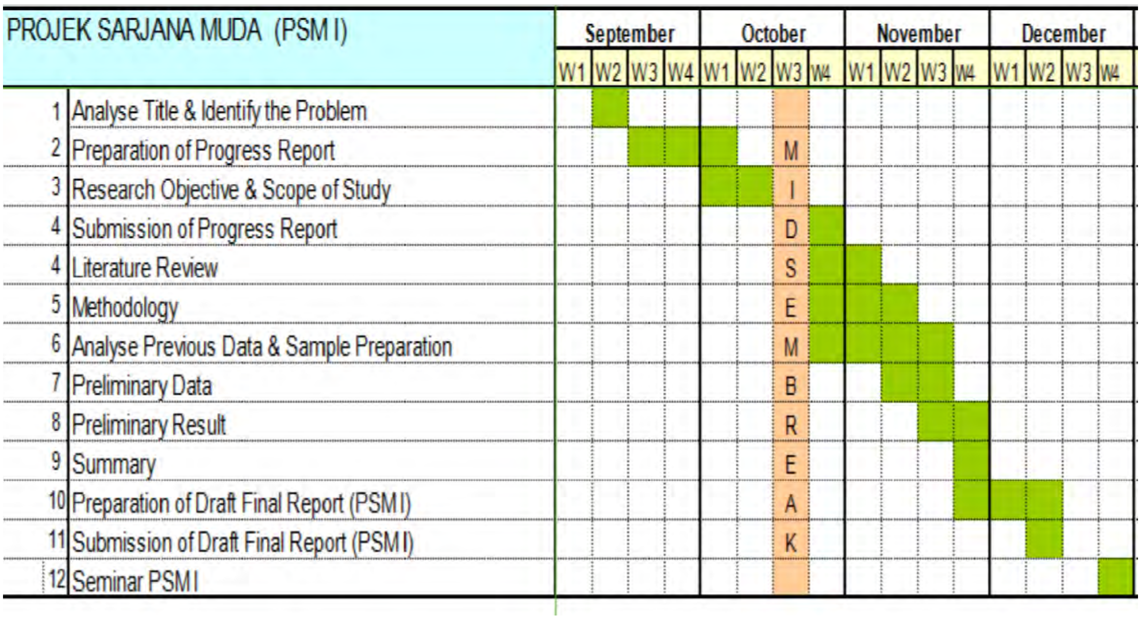

Figure 1.1: Gantt Chart for PSM I

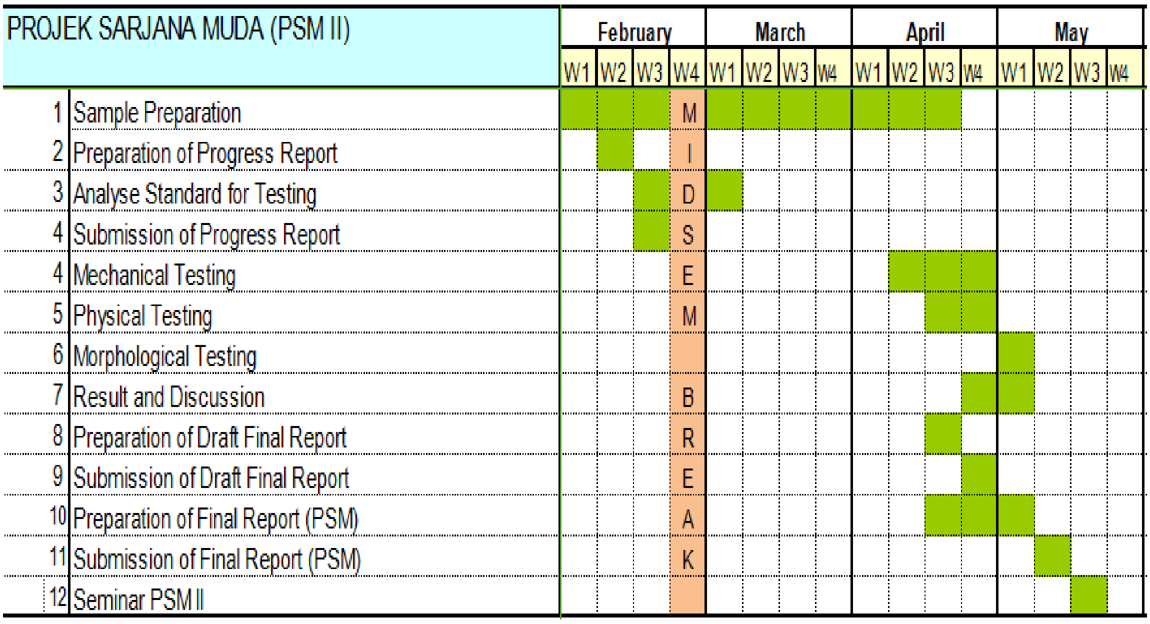

Figure 1.2: Gantt Chart for PSM II

CHAPTER 2

LITERATURE REVIEW

2.0 Composite

As thousands years ago, the function of the composite material have been noticed by the mankind. For instance, ancient brick making that combined straw and brick for building construction was the earliest man-made composite material dating back 6000 years ago. The combined material that used for building construction back then enhanced the structure of the building such as studier and long lasting.

Composites can be defined as material with multifunctional system that have certain characteristic which cannot be found in other discrete material. Besides that, the combination of certain material in order to perform composites are knowingly have their own unique properties. Based on the previous study, composite materials have better heat resistance compared to the other material with single component (Milanese, Cioffi and Voorwald, 2011). Composites also can be defined as individual material that consist of one or more discontinuous phases firmly fixed in continuous phase. Constituent materials is the term related to the composites and classified into two main categories; continuous phase and discontinuous phase. Continuous phase refer to the matrix that also known as binder, while reinforcement agent or filler is in term of discontinuous phase. Plasticizer is an addictive material that plays an important role in order to enhance certain properties in the composites (Padmaraj *et al.*, 2013).

Recently, the mankind show their awareness for the environmental issues such as global warming, pollutions and tremendous usage of earth resources which are not good for