DEVELOPMENT AND CHARACTERIZATION ON PHYSICAL AND ENVIRONMENTAL OF PINEAPPLE LEAF FIBRE REINFORCED THERMOPLASTICS SAGO STARCH COMPOSITE

MUHAMMAD HAFIQH HAKIMI BIN MOHD FUZI
B091910348

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS & TECHNOLOGY) WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT AND CHARACTERIZATION ON PHYSICAL AND ENVIRONMENTAL OF PINEAPPLE LEAF FIBRE REINFORCED THERMOPLASTICS SAGO STARCH COMPOSITE

Muhammad Hafiqh Hakimi bin Mohd Fuzi

Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours

2023

DEVELOPMENT AND CHARACTERIZATION ON PHYSICAL AND ENVIRONMENTAL OF PINEAPPLE LEAF FIBRE REINFORCED THERMOPLASTICS SAGO STARCH COMPOSITE

MUHAMMAD HAFIQH HAKIMI BIN MOHD FUZI

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this “ Development and Characterization on Physical and Environment of Pineapple leaf Fibre Reinforced Thermoplastics Sago Starch Composite, ” is the result of my own research except as cited in the references. The Development and Characterization on Physical and Environment of Pineapple leaf Fibre Reinforced Thermoplastics Sago Starch Composite has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Muhammad Hafiqh Hakimi bin Mohd Fuzi

Date : 11/1/2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours.

Signature :

Supervisor Name : Ts. Dr. Nazri Huzaimi bin Zakaria

Date : 12/1/2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEDICATION

To my precious Allah S.W.T

Who gives me new life, hope and purpose of life

To my beloved father and mother,

Mohd Fuzi bin Ahmad & Rozaini binti Samsudin

To my supervisor,

Ts. Dr. Nazri Huzaimi bin Zakaria

For their continuous advice, support and patirnce while finishing this thesis

And to all my friends,

For their encouragement, cooperation and motivation in completing this thesis

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRACT

Due to the accumulation of non-biodegradable waste, such as disposable items, the demand to design ecologically friendly products has increased recently. Starch is one of the potential candidates since it is readily available, cheap, renewable, and biodegradable. However, the natural properties of sago starch have shown weak mechanical properties. Therefore, the modification of sago starch with glycerol was used to create thermoplastic sago starch (TPSS). Furthermore, the characterizations of the TPSS were investigated, and the best result was obtained from a previous study (Zuraida et al., 2012), which was 75% sago starch and 25% glycerol. Meanwhile, pineapple leaf fibre (PALF) is a flexible plant that may be viewed as a renewable resource for composite production. TPSS was used to create PALF reinforcements with weight ratios of 90:10, 80:20, 70:30, 60:40, and 50:50 TPSS mixes with varying weight percentages of PALF were created using a hot compression moulding at 190˚C for 50 minutes. Several testing, including physical and environmental testing, have been conducted to assess the qualities of bio-composites. The physical test results for moisture content and density shows decreasing pattern when the fibre PALF increase. However, the water absorption shows otherwise when adding fibre content cause the relationship with water increase. While PALF wt% loadings increase, soil burial decreases, despite water solubility statistics suggesting the contrary.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Disebabkan pengumpulan sisa tidak terbiodegradasi, seperti barang pakai buang, permintaan untuk mereka bentuk produk mesra alam telah meningkat baru-baru ini. Kanji adalah salah satu calon yang berpotensi kerana ia mudah didapati, murah, boleh diperbaharui dan terbiodegradasi. Walau bagaimanapun, sifat semulajadi pati sagu telah menunjukkan sifat mekanikal yang lemah. Oleh itu, pengubahsuaian kanji sagu dengan gliserol digunakan untuk menghasilkan kanji sagu termoplastik (TPSS). Tambahan pula, pencirian TPSS telah disiasat, dan keputusan terbaik diperoleh daripada kajian terdahulu (Zuraida et al., 2012), iaitu 75% kanji sagu dan 25% gliserol. Sementara itu, gentian daun nanas (PALF) adalah tumbuhan fleksibel yang boleh dilihat sebagai sumber yang boleh diperbaharui untuk pengeluaran komposit. TPSS digunakan untuk mencipta tetulang PALF dengan nisbah berat 90:10, 80:20, 70:30, 60:40, dan 50:50 campuran TPSS dengan peratusan berat PALF yang berbeza-beza dicipta menggunakan acuan mampatan panas pada 190˚C selama 50 minit. Beberapa ujian, termasuk ujian fizikal dan alam sekitar, telah dijalankan untuk menilai kualiti biokomposit. Keputusan ujian fizikal untuk kandungan lembapan dan ketumpatan menunjukkan corak menurun apabila gentian PALF meningkat. Walau bagaimanapun, penyerapan air menunjukkan sebaliknya apabila menambah kandungan serat menyebabkan hubungan dengan air meningkat. Walaupun beban PALF wt% meningkat, pengebumian tanah berkurangan, walaupun statistik keterlarutan air menunjukkan sebaliknya.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life, and I have finally completed the bachelor’s degree Project 1. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Ts. Dr. Nazri Huzaimi bin Zakaria for tremendous support and supervision during my thesis. Under his direction, I was motivated to explore the world of science and writing.

Finally, I would also like to thank my beloved parents for their endless support, love, and prayers. Finally, thank you to all the individual(s) who had provided me the assistance, support, and inspiration to embark on my study.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TABLE OF CONTENTS

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

اونيۆرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF TABLES

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF FIGURES

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF SYMBOLS AND ABBREVIATIONS

α	-	Amylase
ABS	-	Acrylonitrile-butadiene-styrene
ASTM	-	American society for testing material
CQ	-	Cissus quadrangularis
CMCs	-	Ceramic matric composites
(-COOH)	-	Carboxyl group
˚C	-	Celcius
µm	-	Diameter
Eq	-	Equation
FRCs	-	Fibre-reinforced composites
g	-	gram
g/cm^3	-	Gram per cubic
GPP	-	Glycerol phosphate phosphatases
(-OH)	-	Hydroxyl group
H2S04	-	Sulfuric acid
mm	-	millimetre
%	-	percentage
kg/cm^2	-	Kilogram force per square
Kpa	-	Kilopascal
m	-	Meter
MMCs	-	Metal matric composites
MPOB	-	Malaysia palm oil board
cN/tex	-	Newton per tex
OMCS	-	Organic matric composites
ρ	-	Pressure
PMCs	-	Polymer matric composites
PS	-	Polystyrene
PP	-	Polypropylene
PE	-	Polyethylene

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PC	-	Polycorbonate
PVC	-	Polyvinyl chloride
PEEK	-	Polyether-ether ketone
PLA	-	Polylastic acis
®	-	Registered trademark symbol
NaOH	-	Sodium hydroxide
V	-	volume
XRD	-	Xray-diffraction

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF APPENDICES

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

This section describes the background of the research that has been performed. This section also represents the problem statement, research objectives, and scope research.

1.1 Background

The increasing understanding of the significance of environmental protection has prompted significant research toward developing more natural materials. Regular fibre composites are getting more serious consideration because they have good qualities. Another way composites can help the environment is by using bio-based polymers instead of polymers made from petroleum (Jumaidin et al., 2020). In Malaysia, the pineapple business focuses on the fruits, while the leaves are primarily composted or burnt, so losing valuable potential sources of fibres. Fibre reinforce plastic composites are a combination of two solid materials: a high-strength and -rigidity material surrounded by a similar substance covering and securing it. The stiff material or reinforcement is often composed of a directed component, such as fibre, rods, or sheets, whereas the surrounding material, also known as the matrix, is typically isotropic (Gowayed,2019). Composites comprised of high-strength fibres such as graphite, aromatic polyamide, and glass are widely used in a variety of applications, including aircraft constructions, vehicle components, building materials, and

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

recreational items (Arib et al, 2006). Due to the fact that these fibres are weaker than carbon and aromatic polyamide, they are less costly and biodegradable.

In the future, a limitation of petroleum resources will influence the availability of raw materials, the value of plastic products, the capacity to manufacture them, their lack of biodegradability, and the need to safeguard the natural environment. Recent research has focused on developing biodegradable polymers from renewable resources. Thermoplastic starch (TPS) is one of the bioplastics becoming looked at as a possible replacement for traditional raw materials TPS is produced from starch, is biodegradable, non-toxic, affordable, and easily obtainable (Dang & Yoksan, 2021). Starch is a primary food source for humans(Perin & Murano,2017). They come in semi-crystalline granules, and each plant has a different set of properties. Each plant has unique granules that are different in size and shape. Each granule's interior is composed of growth rings and crystalline and amorphous lamellae. Granules of starch are composed of the polyglucans amylose and amylopectin (Terlow et al, 2020). Amylose has a simple molecular structure since it is composed of glucose residues connected by α -(1,4) connections to lengthy chains including a few α -(1,6)-branches. Amylopectin, the primary component, has the same fundamental structure, but its chains are indeed shorter, and it contains several α-(1,6)-units. It generates a complex, three-dimensional structure, but its purpose is unclear. Amylopectin has been shown to have many different forms over the years. This review shows two of them, called the "cluster model" and "building block backbone model." The structure of starch granules is discussed both positively and negatively (Bertoft, 2017).

Sago starch has received significant interest as a possible ethanol source in recent years. The sago palm accumulates starch in the pith core of its stem(Uthumporn et al., 2014).Sago starch is extracted from the stem of the native Southeast Asian sago palm (Metroxylon sagu) (Zhu, 2019). According to Azmi et al. (2017), sago starch will always be in demand due to its wide range of industrial applications. For instance, in the food business, sago starch is used to make cendol, keropok, lempeng, sago pudding, and tabaloi cookies. Next, the unique qualities of sago starch include its ease of gelatinization and moulding, availability as a renewable resource, low cost, and high starch concentration of 82.94 % (Nasution et al., 2018). Sago starch may be converted into thermoplastic starch or biodegradable plastic under temperature and shearing action (Nasution et al., 2018).

Recent studies in polymer technology are investigating the use of pineapple leaf substitute (PALF) as a reinforcing element in thermoplastics and thermosets because it is cheap and lightweight (Leao et al., 2010). Since pineapple yield is important for fibre production, pineapple is the largest retailer in the market of grown fibre crops (Asim et al., 2015). PALF is equivalent to most sheet and bark fibres in fineness. PALF is a waste that is readily available in Southeast Asia, India, and South America (Pandey, 2005). However, eating only fruits and leaves that contain fibre is often burned or discarded, contributing to environmental pollution, and wasting a potentially important source of fibre.

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The environmental benefits of the fibre-reinforced composite are appealing to producers, consumers, and industry alike. This study aims to development and characterization on physical and environmental of pineapple leaf fibre reinforced thermoplastics sago starch composite.

1.2 Problem Statement

Over the years, everyone has been concerned about the environmental impacts of traditional plastics. Plastics are widely utilized in a variety of sectors, including packaging, electrical and electronic equipment, and the car industry. Plastics are important for product production due to their mobility, light weight, cheap, and aesthetically pleasant characteristics (Cornejo-Ramírez et al., 2018). Besides that, the plastics generated from petroleum resources are non-biodegradable products and harm the environments (Zakaria et al., 2020). As non-biodegradable materials, the disposal of these applications provides a challenging issue after their usage has ended (Todkar & Patil, 2019). Due to all these negative factors, the development of totally biodegradable composites is one of the most viable alternatives to conventional plastics, with the ability to alleviate polymer waste management issues. The goal of this research was to find a solution to this problem by making a biodegradable polymer composite made of 100% renewable materials.

Therefore, in recent times, the production of biopolymers is based on the use of renewable resources; for instance, cellulose, soy, starch, polyhydroxy alkanoates, and polylactic acid (PLA) have all been n investigated as exchange materials to supplant conventional polymers as synthetic (Ghanbarzadeh et al., 2011). Starch is the best raw material for making biodegradable plastics and the composites that they form (Jiang et al., 2020). Starch is the most important polysaccharide polymer used to create biodegradable films due to its capacity to build a continuous matrix and its abundance as a renewable resource (Ghanbarzadeh et al., 2011).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Sago palm also known as (Metroxylonspp) is a plant that is commonly found in the Mukah District, Sarawak. Sago starch is a natural wonder and the most significant raw resource according to its versatility (Ain et al., 2017). By adding heat and shearing force to sago starch, it can be turned into thermoplastic starch. Due to the low temperature at which granular starch reduces, a plasticizer is required during processing (Ahmad et al., 2011). However, thermoplastic starch has disadvantages such as poor mechanical qualities, brittleness, and poor water resistance These limits are due to the hydroxyl group found on the starch molecule, which renders it hydrophilic and performance restrictive (Wahab et al., 2021). To increase the properties of this material, suitable modifications should be made, such as reinforcing it with high-potential natural fibre.

Natural fibre-based composites are being studied a lot because they are good for the environment and have unique properties. Natural fibres are good because they are always available, easy to handle, and biodegradable(Karimah et al., 2021). Pineapple fruits are very important for business, and the leaves are a waste product of the fruit that is used to make natural fibres. PALF will be inspired researchers to explore its potential in composites as a strengthening material (Todkar & Patil, 2019). Next, PALF is a traditional bio-resourced material that has not been wholly used and is also an abundant natural source in Johor, especially in pineapple plantation (Asim et al., 2015).

In addition, producing fully biodegradable material by combining natural fibres, such as PALF, with a polymer matrix based on glycerol would only provide a partial biodegradable product. To make a completely biodegradable substance, it is important to use PALF as a reinforcement in polymer composites that use thermoplastics sago starch as a matrix.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.3 Research Objective

The main goal of this research is to develop and characterize the physical and environmental composites of thermoplastics sago starch reinforced pineapple leaf fiber (PALF). Specifically, the objectives are as follows:

a) To fabricate sago starch reinforced pineapple leaf fibre composite.

b) To investigate physical properties of thermoplastics sago starch reinforced pineapple leaf fiber composite.

c) To find environmental properties of thermoplastics sago starch reinforced pineapple leaf fiber composite.

1.4 Scope of Research

This study attempts to get a deeper understanding of the characteristics of thermoplastics sago starch reinforced pineapple leaf fiber composite in terms of physical and environmental. The approach of this investigation is based on experimental studies. The study is categorized into several phases. The PALF used in this study was from Josapine type and the PALF was bought from Pontian, Johor.

Sago starch was applied in this investigation was taken from the manufacturing type and in powder form. Thermoplastics sago starch was produced using glycerol as a plasticizer. Then, thermoplastics sago starch will be compressed to determine the appropriate compression moulding parameters, i.e., temperature, pressure, preheat period and compression length. The temperature was between 180°C and 190°C. The pressure was between 10 kg/$cm^2$and 30 kg/cm^2, preheat duration was about 6 minutes to 20 minutes.

Thermoplastics sago starch reinforced pineapple leaf fiber was fabricated with five different fibres loading which are 10% to 50%. The preparation TPSS/PALF composites samples were prepared using a compressing moulding technique with random orientation of the PALF. The composite specimens have been examined for their physical and environmental behaviour.

Density, water absorption, and moisture content testing were conducted to analyse the physical behaviour of TPSS/PALF composites. Soil burial and water solubility testing was used to analyse the environment behaviour of TPSS/PALF composites.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section aim to explain the literature from this study further. This section includes prior research on biodegradable fibres reinforced polymer composites, polymer matrices, thermoplastics starch, sago starch, glycerol, and pineapple leaf fibre (PALF). Finding from previous research and the objectives of this study are also discussed in this chapter.

2.2 Matrix

A composite's fibre system is embedded in a material called the matrix, which is mostly a single, solid piece of material (Lee et al., 2021). It goes all the way through and gives a way to connect and hold reinforcements together to make a solid structure. The matrix phase is also known as the composites' continuous step and can be a polymer-metal or ceramic (Santosh Kumar et al., 2015). According to M.Dawoud & M. Saleh (2019), there are two primary levels of categorization for composite materials. The first criteria for classification are the matrix (binder) component. The three primary composite categories are organic matrix composites (OMCs), metal matrix composites (MMCs), and ceramic matrix composites (CMCs). Organic matrix composites (OMC) refer to polymer matrix composites (PMCs) and carbon matrix composites, often known as carbon-carbon composites. Next, the

UNIVERSITI TEKNIKAL MALAYSIA MELAKA