STUDY OF MECHANICAL CHARACTERIZATION ON SAGO STARCH

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DECLARATION

I declare that this thesis entitled “Study of Mechanical Characterization on Sago Starch” 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.

Signature :

Name : Muhammad Farhan Hakim bin Takiudin

Date : 18 January 2022

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 and Technology) with Honours.

Signature	:	
Supervisor Name	:	Ts. Dr. Nazri Huzaimi bin Zakaria
Date	:	18 January 2022

DEDICATION

Dedicated to

My precious mother, Zailina Binti Alias

My honourable father, Takiudin Bin Hamzah

My beloved brothers, Muhammad Amirul Azim Bin Takiudin, Muhammad Aqil Ihsan Bin Takiudin

My beloved sister Nurin Nazifah Binti Takiudin, Intan Norschahirah

Thankyou so much

ABSTRACT

In composites, it is usual to employ petroleum-based polymers to make plastic products, which is bad for the environment because of the non-biodegradable waste effect. To ensure that sago starch is acceptable for use as a matrix, a sago starch fabrication must be conducted to evaluate the mechanical properties of various combinations of plasticizer. The characteristics of sago starch as a biodegradable composite matrix will be described using a variety of experimental approaches. The primary goal of this study is to look at the mechanical properties of sago starch. In this thesis, the physical characterization of sago starch are being studied to determined the suitable matrix paramaters in different percentage of plasticizers. The sample is fabricate by mixing the sago starch with glycerol with 20 wt.% to 40 wt%. The mixing is done manually by using hand and blend using high speed mixer to get a proper mix.Then, the mixture will be transfer into the 160mm × 60mm size of mould and being fabricate by hot press with temperature from 160°C to 180°C for 8 to 25 minutes with the pressure of 25 kg/cm^2. After the sample is fabricate, it will be undergo on mechanical testing procedures for its characterization which is tensile and flexural testing. Tensile testing is done by following the ASTM D-638 and flexural testing is following ASTM D790. Scanning Electrode Microscope (SEM) also been conducted for morphological characteristics. The highest tensile strength achieved shown in tensile testing is when content of sago starch is at 75 wt.%, whereas flexural strength is achieved at the highest when content of sago starch is at 75 wt.%. In conclusion, the addition of glycerol substantially increased the tensile strenght and flexural strenght of the composites matrix.

ABSTRAK

Dalam komposit, penggunaan polimer berasaskan petroleum untuk membuat produk plastik adalah amat lazim, dan ini adalah tidak baik untuk alam sekitar kerana ianya memberikan kesan sisa tidak terbiodegradasi. Untuk memastikan kanji sagu boleh diterima untuk digunakan sebagai matriks, fabrikasi kanji sagu mesti dilakukan supaya sifat mekanikal boleh dinilai pada pelbagai kombinasi plasticizer. Ciri-ciri kanji sagu sebagai matriks komposit terbiodegradasi akan diterangkan menggunakan pelbagai pendekatan eksperimen. Matlamat utama kajian ini adalah untuk melihat sifat mekanikal kanji sagu. Dalam tesis ini, pencirian fizikal kanji sagu sedang dikaji untuk menentukan parameter matriks yang sesuai dalam peratusan pemplastik yang berbeza. Sampel dibuat dengan mencampurkan kanji sagu dengan gliserol dengan 20 wt.% hingga 40 wt%. Pencampuran dilakukan secara manual dengan menggunakan tangan dan campuran dikisar menggunakan pengadun berkelajuan tinggi untuk mendapatkan adunan yang betul. Kemudian, adunan akan dipindahkan ke dalam acuan bersaiz 160mm × 60mm dan difabrikasi dengan melakukan tekanan panas dengan suhu dari 160°C hingga 180° C selama 8 hingga 25 minit dengan tekanan 25 kg/cm2. Selepas sampel difabrikasi, ia akan menjalani prosedur ujian mekanikal untuk penciriannya iaitu ujian tegangan dan ujian lenturan. Ujian tegangan dilakukan dengan mengikuti ASTM D-638 dan ujian lenturan mengikuti ASTM D790. Mikroskop Pengimbasan Elektrod (SEM) juga telah dijalankan untuk ciri morfologi. Kekuatan tegangan tertinggi yang dicapai ditunjukkan dalam ujian tegangan ialah apabila kandungan kanji sagu adalah pada 75 wt.%, manakala kekuatan lenturan dicapai pada tahap tertinggi apabila kandungan kanji sagu adalah pada 75 wt.%. Kesimpulannya, penambahan gliserol telah meningkatkan dengan ketara kekuatan tegangan dan kekuatan lenturan matriks komposit.

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LIST OF SYMBOLS AND ABBREVIATIONS

°C	-	Celcius
CMC	-	Ceramic matrix composite
CO2	-	Carbon dioxide
EP	-	Epoxy
g	-	Gram
LCP	-	Liquid crystal polymer
PC	-	Polycarbonate
PE	-	Polyethylene
PP	-	Polypropylene
PS	-	Polystyrene
PA	-	Polyamide
PMMA	-	Polyacrylics
POM	-	Polyacetal
PSU	-	Polysulfone
PAI	-	Polyamide imide
RS	-	Resistance starch
RDS	-	Rapidly digested starch
SDS	-	Slowly digested starch
TPS	-	Thermoplastic Starch
Wt.%	-	Weight percentages

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CHAPTER 1

INTRODUCTION

1.1 Background

A composite is a substance that is made up of two or more materials that have diverse physical and chemical characteristics (Hazim *et al.*, 2013). The two materials combine to create a stronger and lighter material with their own distinct qualities. Composites are now used in a variety of sectors, including aerospace, automotive, construction, marine, corrosion resistant equipment, and many more (Manohar, 2016). In general, a composite consists of three components which is matrix, the reinforcements, and fine interphase region, also known as the interface (Tri Dung, 2020).

However, sago starch is a biorenewable materials that have been used as a matrix or reinforement in many application (Pappu, Pickering and Thakur, 2019). Composites provide significant benefits in the development of novel processes and materials due to their superior qualities such as ease of production, higher mechanical properties, high thermal stability, and many others. There have been substantial advancements in sago starch modifications and applications during the previous decade. The foundations of sago starch are first described, including extraction, chemical composition, granular and molecular structure, and physicochemical and nutritional qualities (Zhu, 2019).

Plasticizers are organic (often liquid) substances that are largely non-volatile.The polymer's adaptability, extension, toughness, and processability will boost when they're included within a plastic or elastomer (Ibrahim *et al.*, 2019). Glycerol is an important byproduct of the transesterification of biodiesel, the saponification of soap, and the hydrolysis process. Due to the presence of contaminants such as residual catalyst, water, soaps, salts, and esters generated during the reaction, the purity of the glycerol obtained is poor. Due to the rapid expansion of the biodiesel sector, glycerol purification and conversion into useful products has sparked increased attention in recent years (Tan, Abdul Aziz and Aroua, 2013)

This study, mainly aims to construct and analyze sago starch-based biopolymer and plasticizer. This effort also aimed to investigate how the mechanical properties of sago starch with plasticizer give value to waste products while also increasing the starch-based biopolymer's eco-friendliness.

Thus, this research looks at the consequences of employing glycerol as a plasticizer in combination with sago starch on the mechanical properties such as tensile testing and flexural testing. This study also investigating on morphology properties of the sago starch mixed with glycerol as plasticizer.

1.2 Problem Statement

Nowadays, the application of composite has been utilized in many industries whether it is commercial or not. However, there is a drawback that have becoming an issue. In composite, it has been common that to produce plastic product need to use the petroleum-based polymer which is not good to the environmental because of the effect of non-biodegradable waste. To overcome with this problem, the use of natural resource in material must be develop in exchange for the conventional polymer. From this, a biodegradable and friendly environmental composite can be produced so it can potentially solve the non-biodegradable waste disposal problem. In this study, a sago starch has been selected as a composite matrix material. To make sure sago starch is suitable to use as a matrix, a fabrication of sago starch must be made to investigate the mechanical and thermal characteristic in a different combination amount of plasticizer. A several of experimental approach will be used to describe the properties of the sago starch as a biodegradable composite matrix.

1.3 Research Objective

The main aim of this research is to study the mechanical characterization on sago starch. Specifically, the objectives are as follows:

- To fabricate the composite matrix using biodegradable material which is sago starch.
- To investigate the mechanical characteristic of a sago starch in different weight of plasticizer

1.4 Scope of Research

The scope of this research are as follows:

- Prepare and fabricate a matrix sample test from sago starch mix with plasticizer (glycerol) using hot press machine
- Mix from 20 to 40 wt.% of plasticizer (glycerol) into sago starch.
- Conduct tensile and flexural testing to explore the mechanical characteristic.
- Use Scanning Electron Microscope (SEM) for morphology of the material

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there are reviews and studies of various research and journals regarding the development of eco-friendly and biodegradable materials conducted and made by researchers from across the globe. In today's era, modern technology and futuristic inventions continuously to evolve and improve but certain inventions are still not fully capable of fulfilling the criteria of being economically and environmentally friendly.

Excessive consumption of energy has widely affected the global environmental pollution and the public health (McMichael and Beaglehole, 2017). The untenable and unsustainable situation of the natural resources has increased the awareness of environmental consciousness. Therefore, numerous studies about the environmentally friendly materials are completed by researchers in recent years. One of the selected materials, thermoplastics sago starch composite, which has safe and great properties that shows a good alternative compared to the properties of conventional materials (Ahmad, Anuar and Yusof, 2011).

Due to worldwide environmental concerns and greater knowledge of renewable green resources, many efforts have been made to provide and develop eco-friendly and biodegradable materials for the future generation of composite products (Gholampour & Ozbakkaloglu, 2020). Furthermore, as an attempt to overcome the drawbacks of the limitations of conventional plastics, which has very poor degradation rate, and requires high cost to store the non-degradable plastics and in some cases, burning it will lead to the alarming rate of releasing carbon dioxide (CO2) to the air and eventually causes greenhouse effect, thus thermoplastic starch (TPS) is introduced to the eyes of the world.

2.1.1 Composite

Composite contrasted to conventional materials such as metals, ceramics, polymers, etc., composite materials represent a pioneering advance in materials due to their tremendous flexibility in structural material design. They enable and allow you to take advantages of the unique qualities and properties of the constituent materials in order to achieve a final customised behaviour that is one-of-a-kind. As a result, multifunctional design criteria demanded and imposed by many industrial applications have had a significant impact on the substantial development in the use of composites (Ahmed *et al.*, 2018).

Composites can be found naturally on earth. At general, composite materials are described as a heterogeneous mixture of at least two different materials in the micro-scale, featuring new properties other than those of its constituents and, in the macro-scale, a nearly homogeneous structure. The ability to integrate these qualities and properties yields the most defining attribute of a composite material: the ability to modify its qualities to the needs of the intended application and desired purposes (Erden and Ho, 2017).

Composites are now employed in a wide range of applications, including energy, maritime applications, sports, automotive, aerospace and aeronautics, biomedical applications, civil engineering, military, and even in the music business industry (Gholampour & Ozbakkaloglu, 2020). Composites are used to reinforce, minimize and limit the dependence of properties on moisture or humidity, and also prevent retrogradation (Begum, Fawzia and Hashmi, 2020).

Composite materials are commonly referred to in industry as materials with outstanding integrated performance that are made of reinforcement with high strength, high modulus, and brittleness and matrix material with low modulus and toughness through a specific processing procedure. Fibre, sheet, and particle reinforced composite materials, as well as self-reinforced polymer matrix, ceramic matrix, and metal matrix composites, are commonly studied in current materials research. According to research from Begum et al., (2020), composite materials should have the following characteristics: microscopically, it is a non-homogeneous material with a distinct interface, there are significant differences in the performance of component materials, formed composite materials should have a significant improvement in performance, and the volume fraction of component materials should be greater than the volume fraction of composite materials.

2.1.2 Classification of Composite

Based on a research conducted by Nielsen (2005), two classification systems of composite materials are identified. The first system of composite materials is based on the matrix material which consists of three different types of composites: metal matrix composites (MMC), ceramic matrix composites (CMC) and polymer matrix composites (PMC) as shown in Figure 2.1. Below describes the mention matrix composites in the first system.

I. Metal Matrix Composites are composed of a metallic matrix (aluminium, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.

II. Ceramic Matrix Composites are composed of a ceramic matrix and embedded fibres of other ceramic material (dispersed phase).

III. Polymer Matrix Composites are composed of a matrix from thermoset (Unsaturated Polyester (UP), Epoxy (EP)) or thermoplastic (Polycarbonate (PC), Polyvinylchloride, Nylon, Polystyrene) and embedded glass, carbon, steel, or Kevlar fibres (dispersed phase).

The second system of composite materials is based on the material structure. This system also consists of three types of composites: particulate composites, fibrous composites, and laminate composites. Below further explains the functionality and classification of the three mentioned composites in the second system

I. Particulate Composites

Definition : A composite that consists of a matrix reinforces by a dispersed phase in form of particles.

a) Composites with random orientation of particles

b) Composites with preferred orientation of particles.

II. Fibrous Composites

a) Short-fibre reinforced composites consist of a matrix reinforced by a dispersed phase in form of discontinuous fibres (length < 100*diameter).

- Composites with random orientation of fibres
- Composites with preferred orientation of fibres.

b) Long-fibre reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibres.

- Unidirectional orientation of fibres.
- Bidirectional orientation of fibres (woven)