INVESTIGATION OF MECHANICAL BEHAVIOUR ON CORN STARCH

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DECLARATION

I declare that this thesis entitled " Investigation Of Mechanical Behaviour On Corn 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 : NUR ASYRANI BINTI AHAMAD

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 Manufactuing Engineering Technology (Process and Technology) with Honours.

Signature : ....

Supervisor Name : *TS. DR. NAZRI HUZAIMI BIN ZAKARIA*

Date : 18 JANUARY 2022

DEDICATION

This thesis I dedicated to my parents, Mr Ahamad Bin Eni and Mrs. Salhah Binti Haji Tani for the never ending support, love and prayers.

ABSTRACT

Renewable resources are typically plant-based resources such as starch, agar, and cellulose. Starch, which is produced as an energy store by many green plants, has been considered an appealing and ideal candidate to replace petroleum-based materials. The main aim of this research is to investigate the mechanical behaviour of biodegradable matrix derived from corn starch. The objectives of this research is to fabricate the composite matrix using biodegradable derived from corn starch and to understand the fundementals mechanical behaviour and morphological of thermoplastic corn starch. During material preparation, both thermoplastic starch and glycerol must be weight using different type of ratio before mixing it alltogether. Then, the mixture of thermoplastic cornstarch and glycerol were mix together using either hand or high speed blender for about 2 to 3 minutes. The mixture then put into the mould with the dimension of 140 x 60 mm. After prepping the mixture inside the mould, the mould will be put into the hot press machine for pre – heating process for about 15 minutes then hot press at pressure of 25 kg/cm2 with 165ºC of temperature for 15 minutes followed by cooling process for another 15 minutes. The material testing involved in this research is tensile test following the ASTM D-638 and flexural test by following the ASTM D790. As for morphological characteristics, scanning electron microscope (SEM) will be involved. The highest tensile strength for tensile testing is concertration of 70 wt.% thermoplastic corn starch while whereas the highest flexural strength is achieved at concertration of 70 wt.% thermoplastic corn starch. In conclusion, the addition of glycerol substantially increased the tensile strenght and flexural strenght of the composites matrix.

ABSTRAK

Sumber boleh diperbaharui biasanya sumber berasaskan tumbuhan seperti kanji, agar-agar dan selulosa. Kanji, yang dihasilkan sebagai simpanan tenaga oleh banyak tumbuhan hijau, telah dianggap sebagai calon yang menarik dan ideal untuk menggantikan bahan berasaskan petroleum. Matlamat utama penyelidikan ini adalah untuk menyiasat tingkah laku mekanikal matriks terbiodegradasi yang diperoleh daripada kanji jagung. Objektif penyelidikan ini adalah untuk merekacipta matriks komposit menggunakan terbiodegradasi yang diperolehi daripada kanji jagung dan untuk memahami kelakuan mekanikal asas dan morfologi kanji jagung termoplastik. Semasa penyediaan bahan, kedua-dua kanji termoplastik dan gliserol mestilah berat menggunakan nisbah jenis yang berbeza sebelum mencampurkannya kesemuanya. Kemudian, campuran tepung jagung termoplastik dan gliserol digaul bersama sama ada menggunakan tangan atau pengisar kelajuan tinggi selama kira-kira 2 hingga 3 minit. Campuran kemudian dimasukkan ke dalam acuan berdimensi 140 x 60 mm. Selepas menyediakan adunan di dalam acuan, acuan akan dimasukkan ke dalam mesin penekan panas untuk proses pra-pemanasan selama kira-kira 15 minit kemudian tekan panas pada tekanan 25 kg/cm2 dengan suhu 165ºC selama 15 minit diikuti dengan proses penyejukan untuk yang lain. 15 minit. Ujian bahan yang terlibat dalam penyelidikan ini ialah ujian tegangan mengikuti ASTM D-638 dan ujian lenturan dengan mengikuti ASTM D790. Bagi ciri morfologi, mikroskop elektron pengimbasan (SEM) akan terlibat. Kekuatan tegangan tertinggi untuk ujian tegangan ialah gabungan 70 wt.% kanji jagung termoplastik manakala kekuatan lentur tertinggi dicapai pada gabungan 70 wt.% kanji jagung termoplastik. Kesimpulannya, penambahan gliserol telah meningkatkan dengan ketara kekuatan tegangan dan kekuatan lenturan matriks komposit.

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CHAPTER 1

INTRODUCTION

1.1 Background

Composite materials are created by combining two or more materials with distinct properties that do not dissolve or mix together. The different materials in the composite work together to give the composite unique properties (Canyon Hydro et al., 2013). The composites industry is still developing today, with much of the recent development centred on renewable energy. The growth of composite applications is due to a number of factors, the most important of which is that composite-fabricated products are stronger and lighter (Manohar, 2019).

Plastic products made from petroleum-based polymers have had a negative impact on the environment due to the accumulation of non-biodegradable waste (Jumaidin et al., 2017). In the last 20 years, people has been focusing on developing starch-based thermoplastics to reduce the use of non-biodegradable synthetics such as thermoplastics (Averous & Boquillon, 2004). Starch-based thermoplastics are environmentally friendly, cheap to produce and has widely available raw materials and highly biodegradable.

Renewable resources are typically plant-based resources such as starch, agar, and cellulose. Starch, which is produced as an energy store by many green plants, has been considered an appealing and ideal candidate to replace petroleum-based materials. Starch has been considered as the most promising resource for biopolymer development due to its advantages, including the potential of starch in the development of rigid materials, namely thermoplastic starch (TPS) (Jumaidin et al., 2017). Among other known advantages of starch includes its inherent biodegradability, widespread availability by which the raw materials are obtainable even at remote places and also for its low cost production. (Teixeira et al., 2007). Starch can be obtain from variety type of crop like tapioca, corn and potatoes.

Glycerol is used as a plasticiser to produce starch-based biodegradable films where Plasticisers create greater flexibility in the polymer structure by reducing the intermolecular forces and the glass transition temperature of the material, which increases the mobility of the polymer chains in the starch films (Bassi et al., 2020). Glycerol can improve the solubility, lightness, and water absorption of starch films made by casting, as well as create more compact structures because glycerol able to decreased the water vapour permeability of starch films by up to 30%, and more glycerol increased it. Glycerol reduced tension at break and Young's modulus in starch films, but increased elongation. Glycerol can help starch films enhance their mechanical properties (Farahnaky et al., 2013).

1.2 Problem Statement

Petroleum based plastics have been widely used throughout the world. With increased applications, the disposal of waste plastics has become a major problem as it contains toxic chemicals that will harm the earth, air, and water.The accumulation of petroleum-based plastic wastes has caused serious environmental problems because they are neither biodegradable nor renewable (Alkbir et al., 2016). Typical petroleum-based plastic takes a long time to degrade due to the molecular bonds that make the plastic so durable and equally resistant to natural processes of degradation (Aini, 2010).

In order to overcome these problems, several studies are concentrated on the development of new biodegradable matrixs which can be derived from any natural resources.

Several types of bio-based polymers have been developed from natural resources, and starch is one of the most promising materials due to its renewability and widespread availability at a low cost. Polysaccharides such as starches, for example, have many advantages over synthetic polymers in the plastics industry, including low cost, non-toxicity, biodegradability, and availability (Šimkovic, 2013). Starch is a polymeric carbohydrate made up mainly of two biopolymers: amylose (straight chain) and amylopectin (branched chain). However, since starch-based films are brittle and hydrophilic, their processing and application are limited. Starch can be combined with a variety of synthetic and natural polymers to overcome these disadvantages (Manohar, 2019).

1.3 Research Objective

The main aim of this research is to investigate the mechanical and thermal behaviour of biodegradable matrix derived from corn starch. Specifically, the objectives are as follows:

a) To fabricate the composite matrix using biodegradable derived from corn starch

b) To understand the fundementals mechanical behaviour of corn starch

1.4 Scope of Research

The scope of this research are as follows:

- Preparation of matrix sample test derived from corn starch mix with glycerol as plasticizer.
- Conducting tensile test onto the sample to determine the tensile strength of the material.
- Conducting flexural testing onto the sample to determine the stiffness of the material.
- Conducting morphological properties by performing Scanning Electron Microscope (SEM) to reveal the detailed surface characteristics of a specimen and provide information relating to its three-dimensional structure

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Plastic production and consumption have been increasing globally for more than 50 years. In 2019, the global production of plastics reached 368 million metric tonnes, with Europe producing 57.9 million metric tonnes of that total. Plastics are high molecular mass, synthetic organic polymers derived from hydrocarbons extracted from crude oil and natural gas, and they are used for a wide range of applications. More than one third of the entire mass of plastics produced globally is used to make packaging, which typically is not recycled, but instead ends up as waste (Rhodes, 2018).

With such big number of plastic production recorded, it will give negative impacts to the global environment. Plastic pollution can afflict oceans, land, and waterways. It is estimated that about 1.1 to 8.8 million metric tons of plastic waste enters the world ocean from coastal communities every year (Godswill & Gospel, 2019). Ingestion, suffocation, and entanglement of hundreds of marine species are the most apparent and unpleasant effects of marine plastics. Marine wildlife such as seabirds, whales, fishes and turtles, mistake plastic waste for prey, and most die of starvation as their stomachs are filled with plastic debris.

2.2 Composite

2.2.1 Introduction to composite

One of the earliest uses of composite material was by the ancient Mesopotamians around 3400 B.C. (Šerifi et al., 2018) , when they glued wood strips at different angles to create plywood. The concept of “composite” building construction has existed since ancient times where civilizations throughout the world have used basic elements of their surrounding environment in the fabrication of dwellings including mud/straw and wood/clay. This clearly shows that composite has existed among us and played an important role throughout human history, from housing early civilizations to enabling future innovations.

Most composites nowadays provide a lot of benefits compared to traditional material where composite offers industry a world of new opportunities. Composite basically are combination of components or in other word consist of two or more different materials that become stronger when combined. Furthermore, the material used for the combination involves in different properties which result in unique composite properties (Ngo, 2020). The term composite covers a wide range of material combinations, including agglomeration, surface coating or reinforced materials.

Generally, a composite material is composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material (Nagavally, 2017).

Compared to regular materials, composite materials have numerous characteristics that improve or overcome the weakness of a single material which fully give advantages to each material and provide the material new properties. The physical properties of the composite are not isotropic in nature but typically they are anisotropic depend on the direction of force application.

2.2.2 Classifications of composite

Composite material is a material composed of two or more distinct phases. The two phases can be classify as matrix phase and dispersed phase (Nielsen, 2005). Matrix is the primary phase, having a continuous characteristic which usually ductile and less hard phase. The secondary phase (or phases) is embedded in the matrix in a discontinuous form called dispersed phase. Dispersed phase is usually stronger than the matrix, therefore it is sometimes called reinforcing phase.

In addition, composites can classify by the type of material used for the matrix. According to Ibrahim, (2015) composite materials are classified into three types: polymer–matrix composites, metal–matrix composites, and ceramic–matrix composites, and they are widely used in a variety of engineering applications, as illustrated in Figure 2.1.

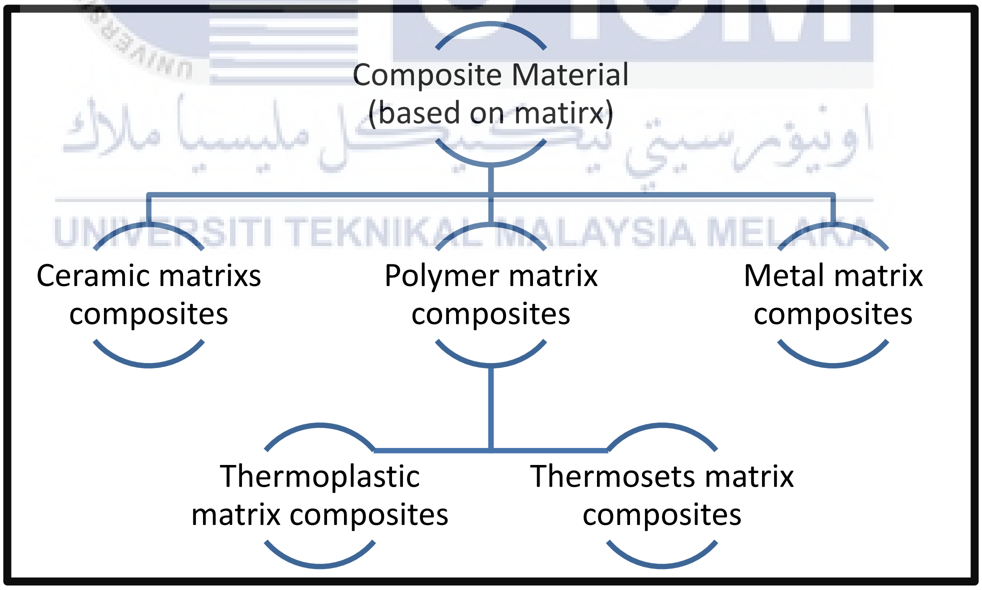

Figure 2.1 Classification of composite based on reinforcement materials (Ibrahim et al., 2015)

Depending on the reinforcement type, composite materials can be classified into particu- late composites, fibre-reinforced composites and struc- tural composites shown in Figure 2.2

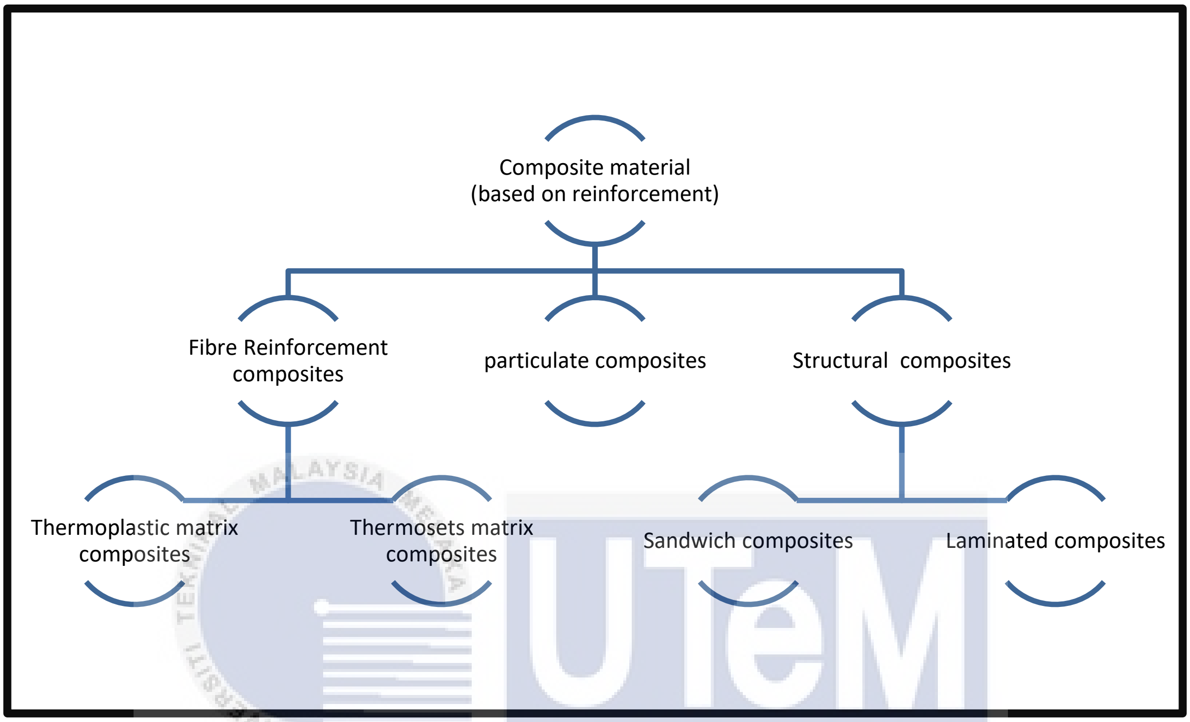

Figure 2.2 Classification of composite based on reinforcement materials (Ibrahim et al., 2015).

2.3 Matrix

2.3.1 Introdution to matrix

The matrix is basically a homogeneous and monolithic material in which is embedded. Matrix is completely continuous and provide medium for binding and holding reinforcements together into a solid. It offers protection to the reinforcements from environmental damage, serves to transfer load, and provides finish, texture, color, durability, and functionality. The role of the matrix is to keep the reinforcement particles in place and to support them. In general, reinforcements affect mechanical and physical characteristics or on any other tailored characteristics improved from the matrix material (Sharma et al., 2020).

2.3.2 Type of matrix

There are three main types of composites developed and widely used in numerous kinds of applications known as polymer matrix composites (PMC), ceramic matrix composites (CMC), and metal matrix composites (MMC) as illustrated in Figure 2.3.

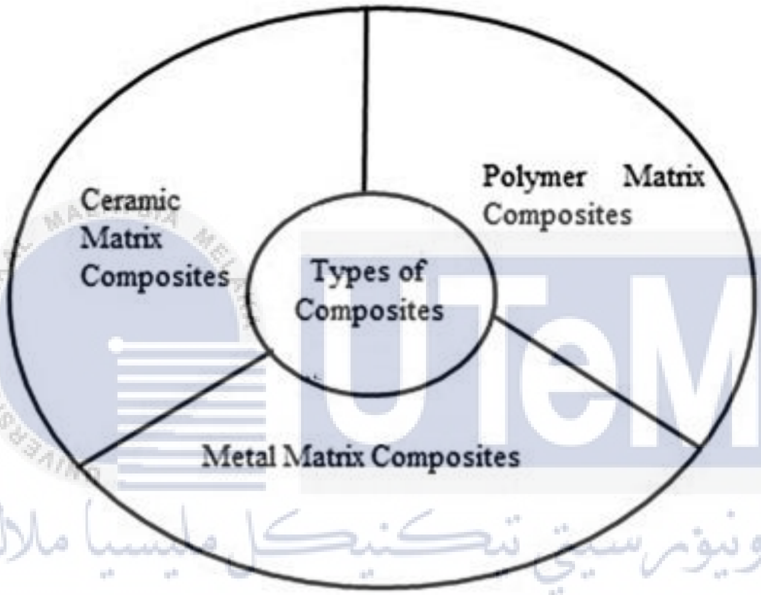

Figure 2.3 Type of matrix (Sharma et al., 2020)

2.3.2.1 Polymer matrix composites (PMCs)

A polymer matrix composite (PMC) is a composite material made up of a variety of short or continuous fibres held together by an organic polymer matrix. Currently, PMCs or known as Polymer matrix are commonly used composite and very popular due to their low cost and simple fabrication methods (Goda et al., 2013) . The matrix in PMCs is typically reinforced with ceramic fibres due to their high strength in comparison to the matrix material. The matrix, reinforcement, process parameters, microstructure, composition, and interphase are all factors that influence the characteristics of PMCs.