THE STUDY OF PHYSICAL AND ENVIRONMENTAL CHARACTERIZATION OF SAGO STARCH MIXTURE WITH GLYCEROL

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

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DECLARATION

I Muhammad Nizamuddin Bin Ja’afar Husni formally declare that this thesis' whole labor is mine. Entitled “The Study of Physical and Environmental Characterization on Sago Starch mixture with glycerol” unless as mentioned in the references, is the result of my own research. This thesis has not been accepted for any degree and is not being addressed at the same time.

Signature : 

Name : MUHAMMAD NIZAMUDDIN BIN JA’AFAR HUSNI

Date : 11/1/2023

APPROVAL

I officially declare that I have reviewed this thesis and that, in my opinion, it is appropriate in scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Process and Technology) with Honours.

Signature : 

Supervisor Name : TS . DR. NAZRI HUZAIMI BIN ZAKARIA

Date : 12/1/2023

DEDICATION

I would like to express my appreciation to my lovely families, especially my beloved wife Nur Nazilah Nazeri, my mother Norhuda Zaidan, and my father Ja'afar Husni Nuruddin for their devotion to educating and supporting me to pursue my education to the degree level. The sacrifices they made for me have made me proud to be a part of them. Further, I want to dedicate this essay to all of my siblings and friends, who have supported me tremendously in encouragement, motivation, and timely counsel in all aspects. Lastly, I want to thank my lecturer, and my supervisor for my PSM (*Projek Sarjana Muda)* Ts. Dr. Nazri Huzaimi bin Zakaria, and my classmate. Throughout my study, they have given me unlimited support and guidance. This study would be impossible to achieve in such a short amount of time without their blessing and encouragement.

ABSTRACT

Plastics are materials that are particularly flexible and have found use in a wide variety of applications, from easy packing to detailed engineering. The production of plastics has overtaken that of steel globally and still expanding. The manufacture of plastic products usually uses petroleum-based polymers and some of petroleum-based plastics are non-biodegradable. Consequently, the environment will be affected because the waste of non-biodegradable does not decompose. Sago starch has been broadly uses from food industry to manufacturing industry. However, there are some disadvantages of sago starch. Hence, this research presents the study of physical and environmental characterization of sago starch mixture with glycerol. The mixtures of sago starch with different weight percentages (wt.%) of glycerol as thermoplastics sago starch (TPSS) bio-composite. The mixtures of sago starch/glycerol contents were at 60/40 wt.%, 65/35 wt.%, 70/30 wt.%, 75/25 wt.%. The mixtures of sago starch / glycerol were made by using hot compression moulding machine to produces TPSS samples. The physical and environmental characteristic were done: Density testing, moisture content testing, water absoprtion testing, water solubility testing and soil burial testing. The physical test graph result show increment pattern on density testing. However, the graph result for moisture content testing, water absoprtion testing and water solubility testing shown decrement pattern. Last but not least, the environment test on soil burial graph result also shown decrement pattern.

ABSTRAK

Plastik ialah bahan yang sangat fleksibel dan telah didapati digunakan dalam pelbagai jenis aplikasi, daripada pembungkusan mudah kepada kejuruteraan terperinci. Pengeluaran plastik telah mengatasi pengeluaran keluli secara global dan masih berkembang. Pembuatan produk plastik biasanya menggunakan polimer berasaskan petroleum dan sesetengah plastik berasaskan petroleum tidak boleh biodegradasi. Akibatnya, alam sekitar akan terjejas kerana bahan buangan yang tidak terbiodegradasi tidak terurai. Pati sagu telah digunakan secara meluas daripada industri makanan kepada industri pembuatan. Walau bagaimanapun, terdapat beberapa kelemahan pati sagu. Justeru, kajian ini membentangkan kajian pencirian fizikal dan persekitaran campuran pati sagu dengan gliserol. Campuran kanji sagu dengan peratusan berat yang berbeza (berat%) gliserol sebagai matriks kanji sagu termoplastik (TPSS). Campuran kandungan pati sagu/gliserol adalah pada 60/40 wt.%, 65/35 wt.%, 70/30 wt.%, 75/25 wt.%. Campuran kanji sagu/gliserol dibuat dengan menggunakan mesin pengacuan mampatan panas untuk menghasilkan sampel TPSS. Ciri fizikal dan persekitaran telah dilakukan: Ujian ketumpatan, ujian kandungan lembapan, ujian penyerapan air, ujian keterlarutan air dan ujian pengebumian tanah. Keputusan graf ujian fizikal menunjukkan corak kenaikan pada ujian ketumpatan. Walau bagaimanapun, keputusan graf untuk ujian kandungan lembapan, ujian penyerapan air dan ujian keterlarutan air menunjukkan corak penyusutan. Akhir sekali, ujian alam sekitar pada hasil graf pengebumian tanah juga menunjukkan corak penyusutan.

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D,d	-	Diameter
%	-	Percentage
g/cm^3	-	Gram per centimeter cubed
$^{\circ}C$	-	Degree Celcius
Wt. %	-	Written abbreviation for weight
V/W	-	Volume of a substance per unit of weight (mass)
ASTM	-	American Society for Testing and Materials

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Plastics are usually produced from synthetic polymers by adding various chemical additives. Synthetic polymers are often created by polymerizing monomers sourced from oil or gas (Halden, 2010) . Plastics are very flexible materials that are also cheap, light, strong, corrosion-resistant, durable, and have excellent thermal and electrical insulation qualities. Due to the variety of polymers and the adaptability of their qualities, a wide range of plastic items may be produced, which benefits society in a number of ways, including technical advancement, energy savings, and several other advantages (Nan et al., 2010). Plastic made from petroleum-based polymers are continually growing in engineering applications, including automotive industries, packaging industries and manufacturing industries. The waste disposal of petroleum-based polymer-based plastic will cause environmental damage in every aspect of life. The amount of plastic waste was increase due to production by plastic manufacture growing industry. Some part of the accumulated waste is recycled, other part is destructed and residue will continue to pollute the environment (Nagy & Kuti, 2016).

The "landfill problem", plastic consumption is a result of an environmental issue (Philp et al, 2013). Since dwindling disposal capacity, increased prices, and stricter environmental regulations, legislation, and in many places of the world, the growing amount of plastic waste has become a crisis. The "accumulation of plastics in oceans" is the second environmental issue. In addition, incineration of plastic releases hazardous pollutants like carbon dioxide and methane into the atmosphere. Moreover, Greenhouse gases (GHGs) play a role in global

warming (Abrol & Adhya, 2017). Further, Plastic is not biodegradable, thus it will stay for hundreds of years in the ecosystem (Halden, 2010). Thus, "Competition for crude oil and energy security" is an economic issue.

Sago is a type of starch that is commonly extracted from the Metroxylon sago palm. It's mostly carbs and low in protein, fat, fiber, vitamins, and minerals. Starch is recognised as one of the most potential natural polymers currently accessible for the development of biodegradable products due to its enticing combination of qualities, including low cost, plentiful availability, thermoplastic behaviour, and biodegradability (Ali & Awale, 2016). Moreover, one of the renewable materials that can be used to create bioplastics or thermoplastics that degrade naturally is starch. The basic material for a bioplastic can be sago starch, which is obtained from sago trunks. In addition, starch is plentiful, has no colour, flavour, or smell, and has no negative effects on either people or the environment (Abd-Aziz, 2002).

A plasticizer is a substance that is applied to another material (typically a plastic or an elastomer) to soften or make it more malleable. Plasticization is the process of altering a polymer's structure to make it more bendable. Starch's drawbacks in terms of melting, high water solubility, processing difficulty, and brittleness require plasticizers to make it suitable for engineering applications. Additionally, little research has been done on sago starch as a viable raw material for bioplastics (Jabbar & Kale, 2015). Glycerol has many applications, one of which is as a plasticizer. To maintain the film delicate, glycerol, a very hygroscopic material, is frequently added to the polymer solution during the film formulation process. By using glycerol will cause its molecules to fill any gaps in the matrix and interact with the starch to create a film polymer. Hence, this research investigates the effects of using sago

starch mixture with glycerol as a plasticizer on the physical, and environmental characteristic.

Bioplastic made from renewable resources with is sago starch as opposed to petroleum-based plastics (Yu & Chen, 2008). Bioplastic is energy efficient. Conventional plastic manufacturing requires less energy. On another side, plastic is created from approximately 4% of the oil consumed globally each year. Cause of the scarcity of oil, the creation of Plastics getting more and more fragile to economic fluctuations (Ezgi Bezirhan Arikan & Havva Duygu Ozsoy, 2015). Besides, bioplastic makes fewer greenhouse gases and contains no contaminants. According to Yu & Chen. (2008), bioplastics contribute significantly to the goal with only 0.49 kg CO2 emitted, and GHG emissions are being reduced for each kilogram of resin manufactured. It reduces when compared to petrochemicals, the potential for global warming is reduced by roughly 80%.

The primary goal of this research is to fabricate the composite matrix using biodegradable material which is sago starch mixed with glycerol or thermoplastic sago starch (TPSS) and investigated the physical and environmental characterization by different ratio percentage of TPSS. Therefore, five experimental methods which are density test, moisture content test, water absorption test, water solubility test and soil burial test have been used to investigated the properties of the TPSS.

1.2 Problem Statement

Non-degradable plastic can lead to waste disposal problems (Ismail et al., 2016). To counter this issue, biodegradable plastic development is needed. In this research, thermoplastic starch-based on sago starch mixture with glycerol. The polysaccharide groups of amylose and amylopectin in sago starch from the sago palm make it easy to gelatinize,

extremely viscose, non-toxic, and biocompatible. However, due to their hydrophilic nature, starch-based materials have a low moisture barrier and others (Rudnik, 2007). Therefore, to increase interfacial adhesion with sago starch, glycerol was used as a plasticizer.

1.3 Research Objective

The research's general objective is to study the physical and environmental characterizations of sago starch mixture with glycerol. The specific objective is:

i. To fabricate sago starch mixture with glycerol.

ii. To investigate the properties of physical on sago starch mixture with glycerol.

iii. To find the properties of environmental on sago starch mixture with glycerol.

1.4 Scope Of Research

The focus of this research is to make a thermoplastic starch (TPSS) sample out of a sago starch and glycerol mixture with different concetration ratio (wt.%). Sago starch powder (25% amylose) and glycerol (95% purity) with a density of 1.261 g/cm3. The ratio of sago starch/glycerol (wt.%): 60/40, 65/35, 70/30, and 75/25. The sample will be poured into a mold with a dimension of 140 x 60 mm. The mold will be placed in a hot press machine by following parameter setting at a pressure of 25 kg/cm2, temperature of 165°C followed by heat time for 30 minutes and cooling for 15 minutes (Zuraida et al., 2012). The resulting samples will be cut into 4 sample testing sizes (10 x 10 x 3 mm) for each ratio of TPSS

The experiment method followed by the standard are:

i. Density testing (ASTM 792).

ii. Moisture content testing (ASTM G21).

iii. Water absorption testing (ASTM D570).

iv. Water solubility testing (ASTM D570).

v. Soil burial testing (ASTM G21).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Bioplastics, often known as biodegradable plastics, are plastics that had been using in the same way as ordinary plastics but can be simply thrown after use since they are dissolved by a microorganism (Nasution & Wulandari, 2021). According to Ezgi Bezirhan Arikan & Havva Duygu Ozsoy. (2015) Bioplastics are 21st-century new materials that will have a significant impact to the world of materials. Bioplastic manufacturing and usage will increase globally ahead. As a result, these materials must be carefully assessed for long-term viability and waste management.

The demand for materials with distinctive and unique qualities is still growing stronger. Materials with good qualities are still being required by industries for several different of applications in a wide range of industrial applications (Nagarajan et al., 2020). Composite are the only type of material that meets the demands of the industry. Composite materials are the only type of material that meets the needs of sector professionals. These materials are created by the desired qualities (Vigneshwaran et al., 2018). Metal, ceramic, and polymer composites are the three types of matrix materials used in composites. Polymer composite materials, among the different types of composite materials, play an important role in today's technology due to their superior physical and environmental features. Moreover, polymer-based Materials are used in a wide range of industries, including aerospace, vehicles, sports equipment, construction, and packaging. Nature fibers have recently been utilized materials

used as reinforcement in the production of polymers matrix composite (PMCs). In bioplastic applications, polymer-based materials have been explored (Ravichandran et al., 2020).

Plastic that has been altered created from a combined with feedstock from agriculture, such as starch, provides a majestic solution to fulfil the qualifications and ensure at least partial breakdown of polymers to impart degradability (Mishra & Rai, 2006). Along with its appealing mix of properties like minimal rates, plentiful availability, and thermoplastic behavior. Starch is one of best potential natural polymers available for the manufacturing of things that are biodegradable (Sarifuddin et al., 2013). The linear amylose and highly branched amylopectin polysaccharide structures found in starch are the amylopectin (highly branched amylose) and amylose (linear amylose), respectively. Crystallinity in native starch is produced by intermolecular interactions and intramolecular hydrogen bonding between hydroxyl groups of starch molecules (Lin & Tung, 2009). In addition, it can respond like a thermoplastic material in the pre-plasticizer such as glycerol; at higher temperatures and lowest shear, it can quickly melt and flow, enables to be extruded or injected like most other synthetic thermoplastic polymers (Prachayawarakorn et al., 2010).

Bioplastics are created from renewable resources including tapioca, corn, potato, sago, etc. They're formed via a variety of microorganisms (Luengo et al., 2003). TPS (thermoplastic starch) is a biodegradable plastic with is relatively new biodegradable plastic. substance. Natural biopolymer starch is a low-cost option. Sago is one of the plants that has the ability to be used as a starch source (Metroxylon sp). Nevertheless, the structure of native starch needs to be properly changed before such material is produced. Because starch is a polymer with many hydroxyl groups, this is required. Because starch contains so many intermolecular and intramolecular hydrogen bonds, it is not regarded as a true thermoplastic. However, it rapidly melted and flowed in the distribution of plasticizers at higher temperatures and shear