Faculty of Mechanical and Manufacturing Engineering Technology

MECHANICAL AND THERMAL PROPERTIES OF THERMOPLASTIC CASSAVA STARCH/BEESWAX REINFORCED WITH SUGARCANE BAGASSE FIBER

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

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MECHANICAL AND THERMAL PROPERTIES OF THERMOPLASTIC CASSAVA STARCH/BEESWAX REINFORCED WITH SUGARCANE BAGASSE FIBER

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DECLARATION

I hereby declare that this thesis entitled "Mechanical and Thermal Properties of Thermoplastic Cassava Starch/Beeswax Reinforced with Sugarcane Bagasse Fiber" 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 : Amirul Hazim Bin Abdul Rahman

Date : …...…….……..

APPROVAL

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

Signature: ……

Supervisor Name: Dr. Ridhwan Bin Jumaidin

Date: …….

DEDICATION

For Allah SWT, our merciful God,

&

For Prophet Muhammad SAW, our divine messenger of Allah SWT,

&

To holy al-Quran, the greatest book in Universe, the beginning of all updated knowledge in mankind,

"And whoever put all of his trust on Allah, He will be enough for him."

(Surah al-Talaq 65:1-3)

&

To my dearest beloved mother and father

&

To my friends who stands right beside me until the end

&

To my mentors, Aida 'Izzati, Dr. Ridhwan Jumaidin

ABSTRACT

In this 21st century, the earth has been polluted severely by the waste of plastic that can be found in the land or ocean. Due to the increasing of synthetic plastic usage, the demand in biodegradable material has been an important issue. Hence, a variety of biodegradable materials were made according to the issues. With today's advanced technology and knowledge, high awareness should be implemented on reserving natural resources and reducing waste by developing more environmentally friendly material. Amongst many biopolymer materials, starch has been recognized as a complete biodegradable material that can be produced by various of plants, which is one of the richest resources that are renewable, biodegradability, and low cost. However, one of the drawbacks of starch is the hydrophilic properties that will absorb moisture from surrounding and interrupts the thermal and mechanical properties of the composite, which limits its potential application. The sugarcane bagasse fiber (SBF) is regarded as one of the agricultural wastes after the sugarcane juice is extracted to be made into sugar and to be consumed. The SBF usually used as natural reinforcement for natural composites due to its natural properties that is capable to degrade alongside the natural matrix material. In order to improve the weaknesses of this material, modification was done through the incorporation of both materials together by mixing the mixture until homogenous and fabricating the material using hot compressing moulding. In this study, the modification is focused on developing thermoplastic cassava starch reinforced with beeswax (TPCS) and sugarcane bagasse fiber (SBF) composite and to study the thermal and mechanical properties. Through the modification, it was found that the mechanical properties such as tensile, flexural, and impact strength have improved significantly with 20 weight % (wt%) of SBF loading into the TPCS. The findings of the tensile properties show that the incorporation of the SBF to the TPCS was proven to increase the tensile strength at a certain percentage. In relation to this finding, the impact and the flexural properties have shown a similar trend. As for the thermal properties based on TGA and DTG shows that higher SBF loading results in more thermally stable material due to the starch and fiber ratio of the samples. It was found that the incorporation of SBF into TPCS have generally improved the properties of the material in terms of thermal and mechanical. The material developed have the potential to be commercialized for packaging and single use product, this is due to the short life of the material when exposed to decomposition. There are a few improvements that could be studied for further enhance the properties of the material and to increase the potential of the material in terms of mechanical and thermal properties and in terms of commercialization of the material.

ABSTRAK

Di abad ke-21 ini, bumi telah tercemar teruk oleh sisa-sisa plastik yang boleh ditemui di darat atau laut. Manusia, haiwan-haiwan dan tumbuh-tumbuhan telah terjejas oleh sisa-sisa tersebut yang boleh menyebabkan penyakit. Pengurangan sumber asli juga harus diambil berat kerana plastik sintetik yang asalnya dari petroleum. Kerana peningkatan di dalam penggunaan plastik sintetik, permintaan bahan biodegradasi telah menjadi isu yang penting. Oleh itu, pelbagai bahan-bahan biodegradasi telah dibuat mengikut isu-isu tersebut. Dengan teknologi dan pengetahuan yang terkini, kesedaran yang tinggi harus diterapkan untuk menyelamatkan sumber semula jadi dan mengurangkan sisa dengan membangunkan bahan yang lebih mesra alam. Di antara banyak bahan biopolimer, kanji telah diiktiraf sebagai bahan biodegradasi lengkap yang dapat dihasilkan dan didapati daripada pelbagai tumbuhan, yang merupakan salah satu sumber terkaya yang boleh diperbaharui, kemampuan biodegradasi, dan serta kos yang rendah. Walau bagaimanapun, salah satu kelemahan kanji adalah sifat hidrofilik yang akan menyerap kelembapan dari sekeliling dan mengganggu sifat haba dan mekanikal komposit, yang mengehadkan potensi penggunaannya. Serat Hampas Tebu (SBF) dianggap sebagai salah satu bahan buangan pertanian selepas jus tebu diekstrak untuk dijadikan gula dan untuk dimakan. SBF biasanya digunakan sebagai pengukuhan semulajadi untuk komposit semulajadi kerana sifat semula jadinya yang mampu mereput bersama bahan matriks semulajadi. Untuk memperbaiki kelemahan kanji, pengubahsuaian telah dilakukan melalui penggabungan kedua-dua bahan bersama-sama dengan mencampurkan campuran sehingga ke tahap homogen dan fabrikasi bahan menggunakan acuan memampatkan panas. Pengubahsuaian difokuskan pada pembangunan komposit termoplastik tepung kanji yang diperkuat dengan lilin lebah (TPCS) dan serat hampas tebu (SBF) dan untuk mengkaji sifat termal dan mekanikalnya. Melalui pengubahsuaian, didapati sifat mekanikal seperti kekuatan tegangan, lenturan, dan impak telah meningkat dengan ketara dengan 20% berat (wt%) SBF yang dimuatkan ke dalam TPCS. Penemuan ciri-ciri tegangan menunjukkan bahawa penggabungan SBF kedalam TPCS akan dapat meningkatkan kekuatan tegangan pada peratusan yang tertentu. Sehubungan dengan penemuan ini, kesan impak dan lenturan telah menunjukkan trend yang sama. Adapun sifat-sifat termal berdasarkan TGA dan DTG menunjukkan bahawa hasil pengisian SBF yang lebih tinggi menghasilkan bahan yang lebih stabil secara termal kerana nisbah kanji dan serat sampel. Telah didapati bahawa penggabungan SBF ke TPCS secara amnya telah meningkatkan sifat bahan dari segi termal dan mekanikal. Bahan yang dihasilkan mempunyai potensi untuk dikomersialkan untuk produk pembungkusan dan penggunaan tunggal, ini disebabkan oleh jangka pendek bahan tersebut apabila setelah dibuang. Terdapat beberapa penambahbaikan yang boleh dipelajari untuk meningkatkan lagi sifat bahan dan meningkatkan potensi bahan dari segi sifat mekanikal dan termal dan dari segi pengkomersilan bahan.

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

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LIST OF ABBREVIATION

TPS	Thermoplastic Starch
TPCS	Thermoplastic Cassava Starch
SBF	Sugarcane Bagasse Fiber
PMC	Polymer Matrix Composite
CMC	Ceramic Composite
MMC	Metal Matrix Composite
NFRP	Natural Fibre Reinforced Plastic
SiC	Silicon Carbide
ASTM	American Society for Testing and Materials
SEM	Scanning Electron Microscope
TGA	Thermo Gravimetric Analysis
DTG	Differential Thermogravimetric Analysis
DSC	Differential Scanning Calorimetry
PLA	Poly-Lactic Acid
FT-IR	Fourier Transform Infrared
SEM	Scanning Electroscopy Microscope

CHAPTER 1

INTRODUCTION

1.0. Background

In this 21st century, the usage of plastic is so widely used, and the world is polluted severely whether in land and ocean. Human, animals, and plants have been affected by the waste that can cause illnesses. Back 1950s, where large scales of plastic usage begun in the series of creating products from plastic. The quick growth of plastic usage on production is at mega scale, outstanding any other man-made materials (Geyer et al., 2017). However, the presence of plastics has resulted in large amount of waste on earth atmosphere that can affect social and economic (Monteiro et al., 2018).

Therefore, to solve this major environmental waste problem, a checklist should be made, on this 21st century, industry must focus in creating and tackling all measures in order to accomplish green technology product in department of material field by entering the world of bio-composite material. With today's technology and knowledge, high precision of awareness should be focused on the natural resources in order to produce polymer that is biodegradable as an alternative substitute of petroleum-based polymers (Averous et al., 2004).

To develop this biodegradable polymer in order of creating greener material, starch should be the main base of the ingredient. Starch has been recognized as a complete biodegradable product by various of plants, which is one of the richest renewable resource out from earth ever existed (Nafchi et al., 2013). The benefits of using starch is, it is low

cost, biodegradability, renewable resource and will never run out of number. The modification can be made by adding plasticizer into starch and reinforce with natural fiber (S. Zhang et al., 2018). The material used is TPS with beeswax as matrix based on study that was conducted by previous researchers has proven that adding beeswax improve the characteristic of moisture absorption and mechanical properties. Modified TPS matrix was used instead of a normal TPS matrix, collected and tested by previous research and study the variable of amount that needs to be mixed for better TPS matrix.

1.1. Problem Statement

As the petroleum getting depleted every single day to create plastic material and being used as fuels for powering automotive engines and machines, it causes the earth's resource to scarce and could led to serious problem as it will take more energy and effort to dig petroleum out of the ground. This will terribly cause gasoline price to rise above average human could afford as countries that produces oil would get short in their oil reserves. Earth needs millions of years to produce petroleum, while demands of petroleum for nowadays is rated at 30 billion of barrels per year, which only last for roughly 50 years of petroleum usage. Consumers nowadays, when they have to pay or spend extra for fuel or product that made of petroleum, usually become displeasure (Asif et al., 2007).

There are few drawbacks of thermoplastic starch, one is the hydrophilic property of the thermoplastic starch. The hydrophilic properties cause the material to absorb moisture higher compared to common plastic with the higher absorption of moisture it will affect the character of the mechanical properties of the thermoplastic starch. Aside from that, the nature of the thermoplastic starch is known to have low mechanical properties compared to common plastic. Due to this facts, a thorough studies are required to improve these properties for a better mechanical property (Ribba et al., 2017).

Thermoplastic are varied, practical, and durable, that is the reason where they are crucial to nowadays modern needs. As human's population continues to increase, so does the amount of garbage were produced. However, presence of plastic product in our earth surface has resulted a large amount of waste that will took at 400 to 1000 years to decompose in landfills. Coastal region is greatly obstructed by this type of pollution as their close to land, where most pollution came from. Ocean are more exposed to plastic pollution as the rivers from land flows almost everything that mainly a plastic product (Monteiro et al., 2018).

1.2. Objective

The objective of this study is to:

i. To develop thermoplastic cassava starch/ beeswax reinforced sugarcane bagasse fiber composites.
ii. To investigate thermal properties of thermoplastic cassava starch and beeswax reinforced with sugarcane bagasse fiber.
iii. To study mechanical properties of thermoplastic cassava starch and beeswax reinforced with sugarcane bagasse fiber.

1.3. Significance of Study

i. To create a new material from renewable resources that will assist in solving the environment issues related to plastic.

ii. To give a value to sugarcane bagasse fiber by utilizing it as a reinforcement in the composite.

iii. Provides new knowledge regarding thermoplastic starch modification.

1.4. Scope of Study

In this research study, cassava starch, sugarcane bagasse fiber, beeswax, and glycerol are the main material that is used. The idea behind in the making of thermoplastic cassava starch mixture is it was created by merging the cassava starch with glycerol, where the glycerol acted as a plasticizer that bonds the thermoplastic cassava starch and it was mixed with variables of suitable amount percentage of glycerol according to the formula. Later, beeswax is added with desired amount of percentage according to the formula. Beeswax in this composite act as resistance components against water and moisture absorption. Then, the sugarcane bagasse is then added to the mixture. It functions as reinforcement for the composite. The process of hot compression moulding will be applied to the mixture in order to fabricate composite. For the investigation of the thermal properties, DSC and TGA test will be performed on the sample and for the mechanical properties, impact test, flexural test, tensile test, FTIR will be conducted on the sample

1.5. Structure of Thesis

The main purpose of the structure this thesis is in the standard format of Universiti Teknikal Malaysia Melaka (UTeM). This whole research offers an introduction, literature review, methodology, result, discussion, conclusion, and recommendation for future and upcoming research. Structure details of the thesis are as follow:

Chapter 1

The problems that associated to this research and the objective of the research are evidently well explained in this chapter. The implication of this research and scopes are explained inside the chapter.

Chapter 2

In this chapter, an extensive literature review on the previous study which is connected to the title of this research thesis. Additionally, the research spaces were also illuminated within the chapter gotten from previous work**.**

Chapter 3

In this chapter, research methodology used in this study presents for the groundwork of materials, testing procedure, and data collection.

Chapter 4

In this chapter, the results of the TPCS, TPCS with Beeswax, and TPS with Beeswax reinforced with SBF composite is presented.

Chapter 5

The conclusion, recommendation, improvement, and product innovation for further research regarding TPCS SBF composite is discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Due to petroleum sources are gets depleting lower each day, researchers are looking forward into creating composites with natural fibers and natural polymer matrices. With conventional plastic that is overproduced means it is one of the biggest waste in the world that would take 400 to 1000 years for the plastic to decompose, it is one of the concern that needs mega awareness on companies and consumers (Alassali et al., 2018). The new material that is developed are created using the agricultural wastes, therefore the cost is lower as it is easy to be obtained (Martinez-pardo, Shanks, Adhikari, & Adhikari, 2017). The wastes are usually disposed, by using it to create a new material, it brings a new purpose for the waste to be used for good purposes instead of being disposed. It is proven that most of waste material can be recycled into a new form without sacrificing raw new material. In this term, it is known that the waste is reduced (Porter & Linde, 1995). Part of the technique applied to improve the performance of the natural composites are generally a big success with the aid of previous researches. Therefore, with the fusion, technology, and knowledge, waste pollution can be reduced and evolve it something useful and practical.