UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical and Manufacturing Engineering Technology

ENVIRONMENTAL AND PHYSICAL PROPERTIES OF THERMOPLASTIC CASSAVA STARCH/BEESWAX REINFORCED WITH SUGARCANE BAGASSE FIBER

Nurul'Ain Haniyun binti Mohamad Fodzi

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

2019

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NURUL'AIN HANIYUN BINTI MOHAMAD FODZI

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

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DEDICATION

Alhamdulillah

Praise to Allah for the strength, guidance and knowledge that was given by Allah for me to complete this study

&

To my beloved parents and families for every support that was given to me

&

To my best friend, Aruhadeyana Arshad for her support to see the blessing given through the hardship, Amirul Hazim, my best friend companion since semester one of Bachelor Degree

&

To my teammates for this study and all the people who supports me through my journey.

ABSTRACT

The non-biodegradable plastic has been causing many environmental to the flora and fauna due to its presence in the environment. Hence, many studies have been conducted recently in search for a new material that is more environmentally friendly and sustainable since the resources for the production of plastic, the petroleum, is nearing its end. Starch have become a focus to the recent studies due to its sustainability, abundant availability and also the capability of the starch to degrade in the natural environment easily. Other than that, the utilization of sugarcane bagasse fiber as the reinforcement have been gaining attention as it could reinforce the strength of the renewable material yet capable of degrading under natural condition and it is also highly available since it is abundantly disposed after the juice extraction. Due to the hydrophilic properties of the starch, the modification of the materials was conducted to improve the properties of the biopolymer. The modification includes the incorporation of the sugarcane bagasse fiber from 10 wt.% to 30 wt.% into the modified TPCS incorporated with beeswax. The physical and environmental properties on the modified material were then analyzed. The modification was successfully developed that starts with hand mixing the starch, glycerol, beeswax and sugarcane bagasse fiber are followed by mixing using a high-speed blender. The mixture then undergoes hot compression molding to form a sample of the new material. The analysis conducted on the new material shows that the incorporation of sugarcane bagasse fiber to the modified TPCS in general have improved the physical and environmental properties of the material. From the water absorption testing it was found that composite with 30wt.% fiber loading absorbed the least water compared to the other samples. However, the thickness swelling results indicate that the sample with 30wt.% fiber loading increase in its thickness the most. As for the moisture absorption found that the increase in fiber loading reduces the moisture absorption of the composite and sample with 30 wt.% fiber loading have the least moisture absorbed. In terms of environmental properties, it was found that the incorporation of 30wt.% sugarcane bagasse fiber reduces the weight reduction of the 2 and 4 weeks soil burial samples. Yet the solubility of the 30 wt.% composite is highest among all of the composites. Based on the results, it was seen that the incorporation of the sugarcane bagasse fiber to the modified thermoplastic cassava starch is improved the composite properties as compared to the matrix material without the reinforcement. In conclusion, the material has better potential to be commercialize is better with the new modification, other than its advantages of lower cost, more environmentally friendly and sustainable. The potential application for such biopolymer would be packaging and product with short lifespan.

ABSTRAK

Plastik tidak terbiodegradasi telah menyebabkan banyak isu alam sekitar disebabkan oleh kepada flora dan fauna di alam sekitar. Oleh kerana itu, banyak kajian telah dilakukan baru-baru ini untuk mencari bahan baru yang lebih mesra alam dan mampan kerana sumber alam untuk pengeluaran plastik, iaitu petroleum, sudah hampir habis. Kanji telah menjadi tumpuan banyak kajian baru-baru ini kerana kelestariannya, ketersediaan yang banyak dan juga keupayaan kanji untuk terurai dalam alam sekitar dengan mudah. Selain itu, penggunaan hampas serat tebu sebagai penguat telah mendapat perhatian kerana ia dapat menguatkan kekuatan dan ketahanan bahan yang berasaskan dari sumber semula jadi yang mampu terurai dalam alam sekitar. Penggunaan hampas serat tebu adalah sangat berguna kerana ia untuk didapati kerana selepas pengekstrakan jus, kebiasaannya ia dilupuskan. Walau bagaimanapun, kerana sifat asas kanji adalah hidrofilik, pengubahsuaian bahan-bahan telah dijalankan untuk meningkatkan sifat-sifat bio-polimer berkenaan. Pengubahsuaian dijalankan dengan menggabungkan serat bagas tebu dari 10wt.% hingga 30wt.% kepada termoplastik kanji ubi kayu yang dicampurkan dengan lilin lebah yang telah dijalankan dalam kajian terdahulu. Sifat fizikal dan sifat persekitaran bahan diubahsuai kemudiannya dianalisis. Pengubahsuaian ini telah dilaksanakan dengan mencampurkan kanji ubi kayu, gliserol, lilin lebah dan hampas serat tebu yang kemudiannya kering dicampur dengan pengadun berkelajuan tinggi. Campuran ini kemudian dimampatkan dengan kaedah pemacuan pemampatan panas untuk membentuk sampel bahan baru. Analisis bahan baru mendapati bahawa penggabungan hampas serat tebu kepada termoplastik kanji ubi kayu yang diubahsuai secara amnya telah meningkatkan sifat bahan dari segi sifat fizikal dan alam sekitar. Dengan ujian penyerapan air, didapati bahawa komposit dengan serat 30wt% menyerap air paling sedikit berbanding sampel lain. Walaubagaimanapun, keputusan perubahan ketebalan menunjukkan bahawa sampel dengan 30wt.% telah berubah ketebalan paling tinggi berbanding sampel lain. Bagi penyerapan kelembapan didapati bahawa sampel dengan serat 30 wt% telah menyerap kelembapan paling minimum antara kesemua sampel. Bagi sifat-sifat alam sekitar, didapati bahawa penggabungan hampas serat tebu sebanyak 30wt.% telah mengurangkan pengurangan berat sampel 2 dan 4 minggu tanaman dalam tanah. Namun kelarutan komposit bagi sampel 30wt.% adalah yang tertinggi dalam kalangan semua komposit. Berdasarkan hasilnya, penggabungan hampas serat tebu ke kanji ubi kayu termoplastik yang diubahsuai telah memperbaiki sifat komposit dibandingkan dengan bahan asas tanpa penggabungan dengan bahan penguat. Sebagai kesimpulan, potensi material untuk dikomersialkan adalah lebih baik dengan pengubahsuaian, selain kelebihannya yang kos rendah, mesra alam dan mampan. Potensi aplikasi untuk bio-polimer adalah untuk menjadi bahan pembungkusan dan produk dengan jangka hayat yang pendek.

ACKNOWLEDGEMENT

Alhamdulilliah, Praise to Allah to the strength and knowledge given to me to finish this study. This research would not be possible for me to complete without the help and support of my family and close friends. A special thanks to my supervisor, Dr. Ridhwan Bin Jumaidin for his guidance and effort to complete this project from scratch and also the experience that was gathered through the participation of UTeM Innovation Expo 2019. I believe with his guidance through this project, I have learned many new knowledges for me to use in the future. I would also like to thank my teammates and also friends that have been giving me support in many ways. Thank you to my mother, Rahmah Binti Harun and my father, Mohamad Fodzi bin Mohd Salleh for supporting my dreams to pursue bachelor's degree. Not forgetting my sisters and my brothers. Also, the help and advice given by all technicians from Faculty of Mechanical and Manufacturing Engineering Technology during the BDP was carried out. Thank you.

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LIST OF ABBREVIATION

PLA	Poly-Lactic Acid
FT-IR	Fourier Transform Infrared
SEM	Scanning Electroscopy Microscope
PGA	Polyglycolic Acid
TPS	Thermoplastic Starch
TPC	Thermoplastic Chitosan
TPCS	Thermoplastic Cassava Starch
MMC	Metal Matrix Composite
PMC	Polymer Matrix Composite
BW	Beeswax
Wt.%	Weight percent

CHAPTER 1

INTRODUCTION

1.0. Background

Nowadays the non-biodegradable plastic has been causing many environmental issues all around the world, from water pollution to the degradation of plastic in landfill (Comăniţă et al., 2016; Derraik, 2002). The problem has drawn attention to the new biodegradable material such as thermoplastic made from natural resources that will eventually degrade in the common environment condition. Green materials are now being developed with the need of material that is safe for the consumer and safe for the environment (Imre et al., 2013).

The recent interest of the material development scientist is the development of biopolymer made from starch. Starch is one of the most popular material to be used to create as thermoplastic with the aid of plasticizer and reinforcement to increase the mechanical, thermal and physical properties. The chemical properties of the material used are commonly with carbon chain will eventually degrade and incorporated to the carbon existed in the soil and environment (Zhang et al., 2013). The reinforcement that is being used in the biopolymer materials are the fibers obtained from plants and animal as it will provide a sufficient reinforcement to the material yet preserving the environmental properties of the material itself.

The development of the biodegradable materials was expected to reduce the environmental issues caused by the conventional thermoplastic and also to provide with a better material that is safe for the consumer and environment use.

1.1. Problem Statement

The use of conventional thermoplastic in everyday life may have been causing many issues to dispose it. The physical and environmental properties of the conventional thermoplastic possess caused difficulties for the material to degrade in the common environment condition. Most of the common issues related to conventional thermoplastic is the plastics accumulation in the landfill caused the volume of the landfill to be overwhelming (Webb et al., 2013). Apart from that, the material used for conventional thermoplastic may consists of hazardous material that will emit dangerous fumes when it is incinerated.

The depletion of petroleum in the world calls for a more sustainable material as the source of material. The availability of starch to be used as the thermoplastic with the addition of plasticizer caught the interest of many researchers as there are not many data related with thermoplastic starch for the thermoplastic starch to be used widely as a consumer product (Sherry et al., 2017) .

However, the poor properties of thermoplastic starch call for a more detailed research data in order to improve the physical properties of the thermoplastic starch yet conserving the environmental properties (Cuevas-Carballo et al., 2017). This is done to ensure that the thermoplastic starch will be able to fulfils the needs for it to be applied as a product yet will be able to degrade in natural condition in less time required by the conventional thermoplastic starch.

Some studies have been carried out in the past in order to study the capability of the new material to replace the conventional thermoplastic. One of them includes the study done by Edhirej et al., (2017) which utilizes cassava peel and cassava bagasse in the thermoplastic cassava starch. It was found that the material produced have good

tensile properties and the material could be further studied as the fiber could be treated chemically. In another study, the degradation behavior of the thermoplastic cassava starch reinforced with agar was studied by Maran et al., (2014). From the study, it was found that the degradation of the material most likely to be influenced by the water uptake of the water into the material and it is possible for the material to degrade under natural environment condition which compliments to the idea where the new material should be able to degrade in short amount of time.

Thus, the main idea in motivating the study is to provide better knowledge regarding the method to improve the drawbacks of the thermoplastic starch. Besides that, it is also done to produce a material will benefit in terms of environmental degradation and renewable material to replace petroleum-based product.

1.2. Objective

The main objective for the study includes:

i. To produce thermoplastic cassava starch/beeswax reinforced with sugarcane bagasse fiber

ii. To study the physical properties of thermoplastic cassava starch/beeswax reinforced with sugarcane bagasse fiber

iii. To study the environmental properties of thermoplastic cassava starch/beeswax reinforced with sugarcane bagasse fiber.

1.3. Significance of Study

The justification of this study are as follows:

i. To provide a better data based on the study carried out on the use of cassava starch as thermoplastic starch modification.

ii. The usage of sugarcane bagasse fiber will provide a use to the fiber instead of disposal of the fiber, hence giving a value to the sugarcane bagasse fiber.

iii. The development of the new material from cassava starch will provide another solution to the problem caused by the conventional thermoplastic.

1.4. Scope of Study

In this study, the raw material used is cassava starch, beeswax, glycerol and sugarcane bagasse fiber. The thermoplastic cassava starch mixture will be formed by combining the cassava starch with glycerol as plasticizer according to the suitable formulation percentage. The desired percentage of beeswax will then be added to the mixture. Beeswax functions as the protective agent against moisture and water absorption. Later on, the mixture is added with sugarcane bagasse fiber as the reinforcement. Hot compression molding will be carried out to produce the thermoplastic starch composite with beeswax reinforced with sugarcane bagasse fiber. The characterization of the physical properties of the material will be done through FTIR, SEM, thickness swelling test, moisture absorption test, density test and water absorption test. While environmental properties characterization will be done through soil burial and water solubility.