UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF NATURAL WAX ON THE MECHANICAL AND WATER RESISTANCE PROPERTIES OF THERMOPLASTIC CASSAVA STARCH

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

By

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours. The member of the supervisory is as follow:

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ABSTRACT

Biodegradation is the process of decomposing a substance through biological processes through decomposition agents such as fungi and chemical processes that occur naturally. Plastics are non-biodegradable materials and this causes them to last a long time. Plastic bags thrown into the sea will cause pollution as well as will cause choking creatures due to eating plastic materials. Biopolymer is a polymer that is naturally found in nature. Starch, protein, and peptides, also DNA and RNA are examples of biopolymers, where monomers are glucose, amino acids and nucleic acids respectively. Cassava starch (CS), which is hundred percent biodegradable, is used in some plastic and film as it is cheap and biodegradable quickly. But the existing starch does not have the strength, flexibility, and processing facilities needed for other uses. Hence, the objective of this study is to enhance the mechanical and physical strength of the substance when mixed into composites. The mechanical properties of thermoplastic CS and beeswax were tested using tensile test. The tensile properties of the material were improved following the incorporation of beeswax. The findings showed that the strength started to increase after 5% of beeswax content were added into TPCS compared to TPCS matrix without beeswax content, while the Young modulus are increased from 5% to 15% of beeswax in thermoplastic CS and decrease a bit at 20% of beeswax content. This shows the contrary result on the elongation trend. The physical properties of the composites were carried out using several tests such as water absorption test, thickness swelling test,

SEM, moisture content analysis, moisture absorption, soil burial, water solubility and TGA. The thermal properties of the materials were slightly improved as the beeswax content increased from 0% to 20%. In terms of physical properties, the addition of beeswax has decrease the moisture content, water absorption and thickness swelling but increase the water solubility due to the hydrophobic and hydrophilic character of both cassava starch and beeswax. After soil burial for 2 and 4 weeks, the composite were decomposed slowly due to the addition of beeswax content. As a whole, the findings from this study have shown that the thermoplastic CS mixed with beeswax has improved the character's function compared to the original material. As complete, thermoplastic CS polymer blend beeswax composites have great potential for biodegradable products such as dispose of wasted materials.

ABSTRAK

Biodegradasi adalah proses penguraian bahan melalui proses biologi melalui agen penguraian seperti kulat dan proses kimia yang berlaku secara semulajadi. Plastik adalah bahan bukan terbiodegradasi dan ini menyebabkan ia kekal lama. Beg plastik yang dibuang ke dalam laut akan menyebabkan pencemaran dan juga akan menyebabkan haiwan tercekik akibat memakan bahan plastic. Biopolimer adalah polimer yang secara semulajadi terdapat dalam alam semula jadi. Kanji, protein dan peptida, juga DNA dan RNA adalah contoh biopolimer, di mana monomer masing-masing adalah glukosa, asid amino dan asid nukleik. Kanji ubi kayu, yang seratus peratus terbiodegrasi, digunakan dalam pembuatan plastik kerana ia murah dan mudah terbiodegradasi dengan cepat. Tetapi kanji sedia ada tidak mempunyai kekuatan, fleksibiliti, dan kemudahan pemprosesan yang diperlukan untuk kegunaan lain. Oleh itu, objektif kajian ini adalah untuk meningkatkan kekuatan mekanikal dan fizikal bahan tersebut apabila dicampur menjadi komposit. Sifat-sifat mekanikal termoplastik kanji ubi kayu dan lilin lebah telah diuji menggunakan ujian tegangan. Sifat tegangan bahan berjaya diperbaiki berikutan penggabungan dengan lilin lebah. Penemuan menunjukkan bahawa kekuatan tegangan mula meningkat selepas 5% kandungan lilin lebah telah dimasukkan ke dalam TPCS berbanding dengan matriks TPCS tanpa kandungan lilin lebah, manakala modulus Young meningkat dari 5% hingga 15% pada kandungan lilin lebah dalam termoplastik CS dan menurun sedikit sebanyak 20 % kandungan lilin lebah. Ini menunjukkan hasil yang bertentangan dengan trend pemanjangan. Sifat-sifat fizikal komposit dilakukan menggunakan beberapa ujian seperti ujian

penyerapan air, ujian bengkak ketebalan, SEM, analisis kandungan lembapan, penyerapan kelembapan, penguburan tanah, kelarutan air dan TGA. Sifat-sifat terma bahan-bahan tersebut sedikit bertambah baik apabila kandungan lilin lebah meningkat dari 0% hingga 20%. Dari segi sifat fizikal, pertambahan lilin lebah telah menurunkan kandungan kelembapan, penyerapan air dan ketebalan tetapi peningkatan kelarutan air disebabkan sifat hidrofobik dan hidrofilik dari lilin lebah dan kanji ubi kayu. Selepas pengebumian dalam tanah selama 2 dan 4 minggu, komposit itu telah diuraikan dengan perlahan disebabkan penambahan kandungan lilin lebah. Secara keseluruhan, penemuan dari kajian ini menunjukkan bahawa termoplastik kanji ubi kayu yang dicampur dengan lilin lebah telah meningkatkan fungsi karakter bahan berbanding dengan bahan asal. Sebagai kesimpulan, campuran polimer termoplastik kanji ubi kayu dan lilin lebah mempunyai potensi besar untuk produk yang boleh terbiodegradasi seperti pembuangan bahan-bahan sisa.

DEDICATION

Specially dedicated to my beloved mother, Norasmah Binti Ismail, my brother and sister and also to all family members, lecturers and friends.

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Alhamdulillah, I am grateful to Allah SWT for His grace to give me the opportunity to complete this Final Year Project. This final year project report is specially prepared for the Faculty of Mechanical and Manufacturing Engineering Technology (FTKMP), Universiti Teknikal Malaysia Melaka. In essence, this final year project report needs to be completed to meet the requirements of the degree program awarded to Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. First of all, I would like to thank my supervisor, Dr. Ridhwan Bin Jumaidin for his sincerity, who has helped and guided me throughout the completion of this final year project. Furthermore, I also thank my mother, Norasmah Binti Ismail for giving me support and encouragement to complete this final project report without giving up. Last but not least, thanks to all the friends who have been involved directly or indirectly and greatly appreciate for supportive cooperation, assistance, and suggestions in the completion of the report from start to finish.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

TPCS	-	Thermoplastic Cassava Starch
PMC	-	Polymer Matrix Composite
E-GF	-	E-Glass Fibre
MMC	-	Metal Matrix Composite
SiC	-	Silicon Carbide
CTE	-	Coefficient of Thermal Expansion
CMC	-	Ceramic Matrix Composite
TPS	-	Thermoplastic Starch
ASTM	-	American Society for Testing and Materials
TGA	-	Thermo Gravimetric Analysis
SEM	-	Scanning Electron Microscope
BC	-	Beeswax Composite
DTG	-	Differential Thermogravimetric Analysis
PLA	-	Polylactic Acid
TPSB	-	Thermoplastic Starch Beeswax

CHAPTER 1

INTRODUCTION

1.0 Background

Over the last few years, ecological awareness involves new materials and products have increased in society. This is due to the production of petroleum-based products that indirectly affect the environment. This problem occurs due to the non-renewable waste accumulation effect. In order to address this worsening problem, a good move was the use of green materials as an alternative step without affecting the ecosystem environment. Biopolymer has been seen as the most satisfying materials for this reason (Lian, Zhang, & Zhao, 2015). It comes from renewable and biodegradable sources which are more environmentally friendly than ordinary polymers.

There are various sources that are obtained and used to enhance biopolymer materials and include starch, cellulose and protein. One of the selected biopolymer sources is starch because it has several advantages such as cheap, renewable, and fully biodegradable resources. Compared to the synthetic fibers, natural fibers have more advantages known as environmentally friendly materials and contain good properties. In other words, these fibers originate from green plants as well as animals originating from nature. There are a lot of various sources of natural fiber such as kenaf, pandanus, starch, wheat, corn, banana, pineapple, palm oil and others.

To choose one fiber to another fiber, there is a difference as it relies on the natural properties. Many factors affect the performance of composites i.e. the properties of mechanical composition, structural state, cell dimension and physical properties. Based on the various applications obtained from the good properties and advantages of synthetic fibers, fiber reinforced composites has gained considerable attention.

Among the advantages of natural fibers is that it will reduce pollution levels that can lead to a health hazard to a minimum. In addition, it can also reduce costs, density and even weight and have environmentally friendly properties. Among the shortcomings of natural fiber composites is that it will shorten the shelf life of composites. This is due to degradation with environmental damage at limited pace and negative effects of degradation pollution.

1.1 Problem Statement

Nowadays, many petroleum-based products have been used in everyday life. The nature of this petroleum-based polymer material has some advantages, which can be durable when used. But on the other hand it has a shortage. About 80% is estimated for use of plastic materials used once only before it is removed. These polymeric materials cannot be decomposed by bacteria or decomposers (Fahma, Sunarti, Indriyani, & Lisdayana, 2017).

So, this will cause the problem of garbage disposal because the polymer cannot be described. Additionally, removable plastics can drain drainage systems and rivers. So, there will be a flash flood. A polymer container that is not planted in the soil can be a breeding ground for mosquitoes. Thus, this can cause dengue fever. Unrefined polymer will be thrown into rivers, ponds and seas (Šárka et al., 2011). As a result, it will be swallowed by animals

and cause them to be choking. Open-burning polymer will release toxic and harmful gases and may cause air pollution and acid rain problems.

However, for the total plastic market, only less than 10% is estimated to be the lasting polymer that is still being formed. One obstacle is that they cost excessively. Compared to those found in petroleum fossil hydrocarbons, natural polymer monomer building blocks contain more oxygen atoms. Indirectly, the properties of polymeric hardness will be affected by the time that will make it difficult for plastic replacements that are more flexible and cheap examples such as polypropylene and polyethylene (Ghanbari, Tabarsa, Ashori, Shakeri, & Mashkour, 2018).

According to current issues, the use of plastic bags has been banned by many countries as a solution to this problem. In solving this problem seriously, recommendations for the development of 100% biodegradable and renewable polymer composites from the natural resources have been proposed in this study (Chassenieux, Durand, Jyotishkumar, & Thomas, 2013). Lately, natural fibers have been given full attention as a substitute for synthetic fibers such as glass and carbon fibers. Natural fibers can also be renewed and cost cheaper and can be a strong reinforcement in the manufacture of composites and for various applications.

1.2 Research Objective

The main objective of this research is to reduce the hydrophilic character of thermoplastic cassava starch by incorporation of natural wax. The definite objectives are:

1. To develop thermoplastic cassava starch *Cera Alba* beeswax composites.

2. To appraise the effect of *Cera Alba* beeswax on the physical and mechanical properties of thermoplastic cassava starch composite.

3. To study the influence of *Cera Alba* beeswax on the physical and environment properties of thermoplastic cassava starch composites.

1.3 Significance of Study

1. Discoveries from this research are might be increase the knowledge to improve biodegradable polymer through thermoplastic cassava starch and beeswax.

2. The eco-friendly polymer enhancement with upgraded properties through this research is anticipated to help in solving natural issues related to alternative materials for petroleum based polymer.

3. This issues related to the petroleum based polymer, for example, natural contamination amid the generation and transfer can be lightened by utilizing a completely biodegradable and sustainable polymer composites got from beeswax and thermoplastic cassava starch.

4. Through this study and on the demand of the society, the industry can take the initiative in commercializing safer polymer products and at the same time preserve the nature.

1.4 Scope of Study

This study will consist of mechanical and physical analysis of TPCS/Beeswax composites. Cassava starch was expanded through the use of glycerol as the plasticizer and turn to thermoplastic cassava starch (TPCS). Characteristics for identification of physical, thermal and mechanical properties will be performed. To find out the properties of this

composite, *Cera Alba* beeswax will be mixed with thermoplastic cassava starch (TPCS). Combination of the composites will be carried out using the mixture of *Cera Alba* Beeswax as the reinforcement while the thermoplastic cassava starch polymer blends as a matrix. Composite properties such as mechanical, thermal and physical will be obtained. The nature of mechanical composite materials may be reduced or increased as well as thermal and physical, depending on the tests performed to obtain results.

The relevant application for the composites developed in this study is a potential application of the composites as biodegradable product such as disposable tray was evaluated through comparison on the primary characteristics against the conventional material and the current thermoplastic starch. Therefore, the other reason for this study is mainly application for short life product.

1.5 Structure of Thesis

The composition of this paper is equivalent to a thesis format recognized by the Universiti Teknikal Malaysia Melaka. This thesis have been divided into several important chapters covering part introduction, literature review, methodology, results & discussions as well as the conclusion including recommendation for future research. The explanation of the chapter has been described as follows:

Chapter 1: Introduction

The problems discuss in this research and the research objectives were clearly stated in this chapter. The significance of this work and the scope of study were also elaborated within the chapter.