Faculty of Mechanical and Manufacturing Engineering Technology

EFFECT OF COGON GRASS FIBRE ON THE THERMAL, PHYSICAL AND ENVIRONMENTAL CHARACTERISTIC OF THERMOPLASTIC CASSAVA STARCH

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

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This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Degree in Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

Signature :…….....

Supervisor Name : Dr. Ridhwan Bin Jumaidin

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DEDICATIONS

The sake of Allah, the Creator.

To Al-Quran, the greatest source of knowledge.

To my beloved parents who never stop giving support and a great source of inspiration.

To my supervisor, the one who has been a constant source of knowledge.

To my all my friends who encourage and give their support.

ABSTRACT

In recent, increasing environmental issues led to greater attention on the development of biodegradable materials. Biopolymer produced from renewable natural resources is a good alternative material for replacing petroleum-based polymer since it biodegradable and environmentally friendly. Biopolymer-based on starch is one of the most promising due to the wide availability, low cost, renewable, biodegradable and abundant in future. Cassava starch that produced from cassava is considered as a source of renewable starch. Nevertheless, the biopolymer produced from cassava starch has some drawbacks such as the poor physical properties and high water absorption has limited its potential application. One interesting method to solve this issue by using natural fiber as reinforcement for thermoplastic starch (TPS). Various modification methods were used to improve the properties of thermoplastic cassava starch (TPCS) which is blending cassava starch with glycerol and reinforcement of TPCS with cogon grass fiber. TPCS and cogon grass fiber were successfully developed by using dry-mixing and compression molding method. The modification of TPCS with cogon grass fiber is performed by incorporating a different amount of cogon grass fiber (1, 3, and 5 wt. %) into the polymer matrix. The mixture of TPCS and cogon grass fiber are prepared by pre-mixing using a high-speed mixer at 3000 rpm for 12 min. The resulting mixture is pre-mixed at 160°C for 35 min by using a compression molding machine under the load of 10 tonnes. The thermal, physical and environmental properties were investigated. Thermogravimetric analysis (TGA) analysis is used to study the decomposition temperature and thermal stability of materials. The thermal properties of the composite were reduced as the cogon grass fibers increase from 0 to 5%. The physical of this composites is obtained by using water absorption testing to measure the quantity amount of water absorbed by materials. Moisture absorption test is to measuring the moisture that absorbs by materials while swelling testing to determine the swelling ratio of material when immersed in water. The addition of cogon grass fibers has improved the characteristic of the composite for physical properties. In term of environmental properties, the water solubility test and soil burial test are used to determine loss of weight because of moisture and microorganism activity. The inclusion of fibers into TPCS has reduced the solubility of the composite in water and reduced the biodegradability of materials after 2 and 4 weeks. Overall, the analysis from the current study shows that TPCS modified with the inclusion of cogon grass fiber has shown improved functional characteristics than the original materials. In conclusion, the TPCS polymer reinforced with cogon grass fiber are very interesting analysis and good materials for a potential biodegradable product with intensify properties.

ABSTRAK

Sejak kebelakangan ini, isu-isu alam sekitar yang semakin meningkat membawa kepada kesan yang besar terhadap perkembangan bahan biodegradasi. Biopolimer yang dihasilkan daripada sumber semula jadi boleh diperbaharui adalah bahan alternatif yang baik untuk menggantikan polimer berasaskan petroleum kerana ia boleh dibiodegradasi dan mesra alam. Biopolimer berasaskan kanji adalah salah satu cara yang berkesan kerana mudah didapati, kos rendah, boleh diperbaharui, biodegradasi pada masa hadapan. Kanji yang dihasilkan dari ubi kayu dianggap sebagai sumber kanji yang boleh diperbaharui.. Walau bagaimanapun, biopolimer yang dihasilkan daripada kanji mempunyai beberapa kelemahan seperti sifat fizikal yang lemah dan penyerapan air yang tinggi telah menghadkan potensinya. Satu kaedah yang menarik untuk menyelesaikan masalah ini dengan menggunakan serat semulajadi sebagai pengukuhan untuk tepung termoplastik (TPS). Pelbagai kaedah pengubahsuaian telah digunakan untuk meningkatkan sifat termoplastik ubi kayu (TPCS) yang menggabungkan kanji dengan gliserol dan penguat TPCS dengan serat lalang. TPCS dan serat lalang berjaya dihasilkan dengan menggunakan kaedah pencampuran kering dan mampatan. Pengubahsuaian TPCS dengan serat lalang dilakukan dengan memasukkan nisbah yang berbeza (1, 3, dan 5% berat) ke dalam matriks polimer. Komposit TPCS dan serat lalang dijalankan dengan pra-pencampuran dengan menggunakan pengadun berkelajuan tinggi pada 3000 rpm selama 12 minit. Komposit yang dihasilkan pada suhu 160 ° C selama 35 minit dengan menggunakan mesin pengacuan mampatan di bawah beban 10 tan. Sifat haba, fizikal dan persekitaran dikaji. Analisis termogravimetrik (TGA) dijalankan untuk mengkaji suhu penguraian dan kestabilan terma bahan. Sifat-sifat terma komposit berkurang kerana serat lalang meningkat dari 0 hingga 5%. Fizikal komposit ini diperoleh dengan menggunakan ujian penyerapan air untuk mengukur jumlah kuantiti air yang diserap oleh bahan. Ujian penyerapan kelembapan adalah untuk mengukur kelembapan yang diserap oleh bahan dan ujian bengkak ketebalan untuk menentukan nisbah bahan apabila direndam dalam air. Penambahan serat lalang telah meningkatkan sifat komposit untuk sifat fizikal. Dari segi sifat persekitaran, ujian kelarutan air dan ujian penguburan tanah digunakan untuk menentukan kehilangan berat bahan kerana kelembapan dan aktiviti mikroorganisma. Kemasukan serat ke dalam TPCS telah mengurangkan komposisi kelarutan dalam air dan mengurangkan biodegradabiliti bahan selepas 2 dan 4 minggu. Keseluruhannya, analisis dari kajian semasa yang dimodifikasi TPCS dengan kemasukan serat lalang telah menunjukkan ciri-ciri fungsian yang lebih baik daripada bahan asal. Kesimpulannya, polimer TPCS yang diperkuat dengan serat lalang adalah analisis kajian yang sangat menarik dan bahan yang baik untuk produk biodegradasi serta berpotensi meningkatkan sifat bahan.

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LIST OF ABBREVIATIONS

CB	-	Cassava bagasse
CNRL	-	Concentrated Natural Rubber Latex
CMC	-	Ceramic Matrix Composite
CS	-	Cassava starch
DMA	-	Dynamic Mechanical Analysis
DSC	-	Differential Scanning Calorimetry
EMMT	-	Activated-Montmorillonite
ENR	-	Epoxidized natural rubber
EPS	-	Expanded polystyrene
FRP	-	Fiber reinforced polymer
FT-IR	-	Fourier-Transform Infrared Spectroscopy
MFI	-	Melt flow Index
MMC	-	Metal Matrix Composite
PBAT	-	Polybutylene Adipate Terephthalate
PCL	-	Poly Caprolactone
PMC	-	Polymer Matrix Composite
PLA	-	Poly Lactic Acid
PLGA	-	Poly Lactic Acid co Poly Glycolic Acid
PGA	-	Poly Glycolic Acid
SEM	-	Scanning Electron Microscope
SMG	-	MAN-glycidyl methacrylate
SPF	-	Sugar palm fiber
TEM	-	Transmission Electron Microscopy
TGA	-	Thermo gravimetric analysis
TPCS	-	Thermoplastic cassava starch

TPCRS	-	Thermoplastic cornstarch
TPRS	-	Thermoplastic rice starch
TPS	-	Thermoplastic starch
WVTR	-	Water Vapor Transmission
XRD	-	X-Ray Diffraction

CHAPTER 1

INTRODUCTION

1.1 Background

In recent years, thermoplastic starch (TPS) based composite has become the developing environmental friendly product and interesting for packaging and material applications. Aside from the characteristic of its biodegradability, starch is promising as a renewable resource that having the ability to change or replace petroleum-based plastic packaging. However, TPS has some weakness or limitations in term high water and moisture absorption, low flexibility. To solve this issue, many fillers have been used to keeping the improvement properties of the TPS such as the addition of fibers (Bootklad & Kaewtatip, 2013). Natural fibers that possess good characteristics properties including biodegradability, low density, low cost, recyclability, and availability becoming an alternative to produce green composites from the combination with other materials, also can replace petroleum-based products. According to Prachayawarakorn *et al.*, (2013), the physical properties of thermoplastic cassava starch (TPCS) mixed with jute or kapok were improved. This was proved by water absorption test whereby by the addition of cellulosic fib, the TPCS water absorption with kapok and jute fiber composites were decreased.

Cogon grass (*Imperata cylindrica*) can consider being one of the ten most awful weeds in the world because of its ability to effectively colonize, spread, and displace desirable vegetation. By utilizing as a fiber in the production of composites can control this disruption of ecosystem besides can make use of this plant. Cogon grass has been proved to have good weather resistant due to its use as a material for the roof in Thailand

(Ruksakulpiwat, Wanasut, Singkum, & Ruksakulpiwat, 2013). This study reported on the properties of TPCS with glycerol as the plasticizer and cogon grass fiber as the reinforcement to analyses the thermal, physical and environmental.

1.2 Problem statement

Population growth has dramatically increased the usage of different types of petroleum-based polymer for packaging materials that led to the environmental problem because of their large quantities and disposal problem whereby the thermoplastic does not biodegradable for ages. These waste can be classified as a type of material that cannot be a breakdown by water, sunlight and ground soil which brought a serious issue to the wildlife, society and environmental (Locklin, 2017). Moreover, another one example of concerning issue is air pollution besides they also produce greenhouse gas called methane which can increase the global temperature. Aside from the air pollution and global warming, the used of non-biodegradable packaging materials can cause flooding since they do not decompose, they can prevent proper drainage and clog the sewage system. The human race and another living orgasm could be wiped away if this pollution and environmental issues are not resolved completely. Hence, the purpose of this research is to solve and overcome this issues by developing a biodegradable and renewable polymer from a natural source.

Imperata cylindrica, usually known as cogon grass and also called as 'lalang' in Malaysia and 'alang-alang' in Indonesia is recognized as being one of the ten most exceedingly bad weeds in the world. These species exist in a large range of habitat that includes grassland and degraded forest. The cogon grass appears to consists of leaf and stem fiber in its outer layer, which is used as a reinforcement (Srinivasababu & Kumar, 2015). MacDonald, (2004) reported that the leave of cogon grass can be considered to be beneficial material that can be used for building and for homes roof beside can be livestock feed for

farm animals such as buffalos, cows, and goats. The cogon grass fiber was proved to be productive material as reinforcing fiber in epoxidized natural rubber (ENR) composites (Ruksakulpiwat et al., 2013). With the incorporation of the fiber with ENR, significantly enhanced the properties of mechanical for the composites. TPS is fully degradable material. Unfortunately, it has various weakness properties such as it has high shrinkage and high moisture uptake in the mold. It also shows high viscosity that can cause its process more hard way than conventional polymers besides the mechanical properties are a very week (Jutarat Prachayawarakorn et al., 2013). The TPS properties can be raise by the addition of natural fibers as they were reinforced into a matrix that led to achieving a good interfacial bonding between them without additives, besides obtaining of degradable composites.

1.3 Objective

The aim of the study is to develop a biodegradable natural resource polymer. The details of the objective are:

1. To develop new renewable materials made up from thermoplastic cassava starch (TPCS) reinforced with cogon grass fiber.
2. To investigate the thermal properties of thermoplastic cassava starch/cogon grass fiber composite.
3. To characterize the effect of cogon grass fiber on the physical and environmental properties of thermoplastic cassava starch.

1.4 Significance of the study

1. This analysis has explored new potential applications from waste materials of cogon grass fiber as reinforcement to the matrix.
2. The researchers from the present study are to increase the understanding of thermoplastic cassava starch and cogon grass fiber in developing of a biodegradable polymer.
3. The development of renewable polymer composites from thermoplastic cassava starch and cogon grass fiber can solve the environmental pollution issue that comes from the petroleum-based polymer.
4. The potential of the biodegradable polymer has been recognized by many researchers since their abilities to overcome the limitation of petrochemical resources in the future.
5. This study has a high potential for commercialization due to the low cost by using wastes materials.

1.5 Scope of study

In this study, thermoplastic cassava starch and cogon grass fiber were characterized for their thermal, physical and environmental. Thermoplastic cassava starch was developed by using glycerol as plasticizer. The analysis of the composites was carried out by using cogon grass fiber as reinforcement and the thermoplastic cassava starch as a matrix. The thermal, physical and environmental properties of the composites are studied. The thermal properties test are carried out to learn the property of the material composites to conduct heat using thermo gravimetric analysis while the physical properties will be accomplished by using moisture absorption test, water absorption test, and swelling test. Biodegradable properties of thermoplastic starch with cogon grass fiber can be determined by using

environmental test i. e soil burial test and water solubility test. Therefore, the potential application of the composites as biodegradable polymer was evaluated by using the present thermoplastic starch and common material on the fundamental characteristics.

1.6 Structure of thesis

The format of this thesis is in following the format of Universiti Teknikal Malaysia Melaka. The study was separated into three different chapter which has an introduction, literature review, methodology, preliminary results for this study. The details of each chapter are as follows:

Chapter 1

The problem that introduces this study and the objective of this research was clearly explained. The scope and significance of the study also made detailed in this chapter.

Chapter 2

This section explained details an extensive literature review that relevant to this thesis study. Moreover, the research gaps acquired from all the reviews were also elaborated within the chapter.

Chapter 3

This section shows the methodology used in this analysis for the readiness, testing and data accumulation of all materials.

Chapter 4

This chapter presents the results and discussion of the research for thermoplastic cassava starch/cogon grass fiber composite and their properties including the analysis and presentation of data, the discussion of the results, and the correlation between the findings.

Chapter 5

This chapter represents overall conclusions from the whole study and analysis as well as recommendations for future improvement of the research and potential commercialization of the product.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter demonstrates all the findings of many literature reviews, which can be obtained from many reliable sources such as the Internet, journals, articles and books on the subject of this study. This section includes findings of the overview type of materials, composites, properties, and its process. Generally, a fiber reinforced polymer (FRP) can be defined as composite material containing a high strength fibers such as glass and carbon were mixed together with the polymer matrix. In recent years, various researched had been done for the natural fibers that used as a reinforce elements in composites and polymers. As a replacement for synthetic thermoplastic, biopolymers based on starch have been of importance due to low costs, low density, and renewability. Bio-based products can be utilized as a part of development, automotive part, and furniture are widely used from the bio-based product which is presently dominated by petroleum-based products. Thus, petroleum-based products have an alternate material that can substitute it which is coming from natural fibers either alone or mix with other substances to generate green composites.