UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BIODEGRADABLE PACKAGING DERIVED FROM COCONUT LEAF FIBER : MECHANICAL PROPERTIES

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in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled "Biodegradable Packaging Derived From Coconut Leaf Fiber : Mechanical Properties" is the result of my own research, with the exception of the references. The thesis has not been accepted for any degree and is not being submitted concurrently with another degree's candidature.

Signature :

Name : Che Amimi Yasmin Binti Che Asudin

Date : 18 January 2022

APPROVAL

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

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Supervisor Name	:	Dr. Ridhwan Bin Jumaidin
Date	:	18/1/2022

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, families and my friends for every support that was given to me.

&

To my supervisor, Dr. Ridhwan Bin Jumaidin for his guidance and advice in completing this research.

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To all people who support me throughout my journey.

ABSTRACT

Nowadays, environmental awareness has increased in society that involving new materials and goods. This awareness is related to creating petroleum-based products, particularly those used to produce short-life products such as disposable eating utensils, food packaging, and bags with an indirect environmental impact. Furthermore, this issue arises because the use of non-biodegradable plastic contributed to environmental issues such as water pollution, air pollution, and landfill problems. Hence, the need to create more environmentally friendly products is crucial, and the development of the quality of the materials increased from days to days to overcome this problem. Numerous studies have been conducted on biopolymers derived from renewable resources because they are one of the most promising materials for replacing petroleum-based polymers.The objective of this study is to produce biodegradable thermoplastic cassava starch reinforced with coconut leaf fiber composite. Second, to investigate the thermal testing and mechanical testing of biodegradable thermoplastic cassava starch reinforced with coconut leaf fiber composite and to produce biodegradable packaging from the coconut leaf fiber. Natural fibre is a biodegradable natural fibre that is used as a reinforcement in polymeric composites mostly due to its low production costs, improved hardness, excellent fatigue resistance, good thermal and mechanical resistivity, and biodegradability.Hence, all materials were uniformly mixed before being fabricated with hot compression moulding at 155 °C for 60 mins. The fundamental properties of TPCS reinforced by coconut leaf fibre biopolymer composites were next studied in order to evaluate their potential as biodegradable reinforcements. The appearance of coconut leaf fibre was discovered to have an effect on the attributes of the samples. The incorporation of beeswax and coconut leaf fiber improves the weaknesses of cassava starch biopolymer, and the composition ratio is 10 – 40 wt.%. Moreover, it is expected to improve mechanical properties. This research investigates mechanical testing by using such as tensile and flexural test while thermal testing consist thermogravimetric analysis (TGA). For other testing consists Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) against the behavior of TPCS reinforced by coconut leaf fiber composite. In generally, a similar trend in the tensile and flexural characteristics of the TPCS coconut leaf fiber composite was observed. Addition of fiber at 30% shows the maximum tensile and flexural strength and modulus while tensile strain, it was found that at 10% shows the maximum and for the flexural shows that, at 20% shows the maximum result. Besides that, the characterization of TPCS reinforced with coconut leaf fiber was done by using SEM and FTIR. The presence of chemical bonding in the samples is shown by FTIR. Hence, it was found that there the present of O-H, C-H and C-O bands in the samples. Moreover, microstructures of the composite are shown by SEM micrographs as fiber concentration increases. The presence of fiber break which aid in the improvement of the mechanical properties. Hence, in term of thermal, the properties were improved with addition of the fiber, as shown by higher residue content. In conclusion, the study presented potential application fields of TPCS reinforced by coconut leaf fiber biopolymer composites, particularly in packaging applications. As a result, this material has the potential to be a viable replacement for non-biodegradable bioplastics in the future, and natural waste can be fully exploited.

ABSTRAK

Pada masa kini, kesedaran alam sekitar telah meningkat dalam masyarakat yang melibatkan bahan dan barang baru. Kesedaran ini berkaitan dengan mencipta produk berasaskan petroleum, terutama yang digunakan untuk menghasilkan produk jangka pendek seperti peralatan pakai buang, pembungkusan makanan, dan beg dengan kesan persekitaran tidak langsung. Tambahan pula, isu ini timbul kerana penggunaan plastik tidak terbiodegradasi menyumbang kepada isu alam sekitar seperti pencemaran air, pencemaran udara, dan masalah tapak pelupusan. Oleh itu, keperluan untuk mencipta lebih banyak produk mesra alam adalah penting, dan pembangunan kualiti bahan meningkat dari hari ke hari untuk mengatasi masalah ini. Banyak kajian telah dijalankan ke atas biopolimer yang diperolehi daripada sumber yang boleh diperbaharui kerana ia adalah salah satu bahan yang paling menjanjikan untuk menggantikan polimer berasaskan petroleum. Objektif kajian ini adalah untuk menghasilkan termoplastik kanji ubi kayu terbiodegradasi diperkukuh dengan komposit gentian daun kelapa. Kedua, untuk menyiasat ujian haba dan ujian mekanikal termoplastik kanji ubi kayu terbiodegradasi diperkukuh dengan komposit serat daun kelapa dan untuk menghasilkan pembungkusan terbiodegradasi daripada serat daun kelapa. Gentian asli ialah gentian semula jadi terbiodegradasi yang digunakan sebagai tetulang dalam komposit polimer kebanyakannya disebabkan oleh kos pengeluarannya yang rendah, kekerasan yang dipertingkatkan, rintangan lesu yang sangat baik, kerintangan terma dan mekanikal yang baik, dan kebolehbiodegradan. Oleh itu, semua bahan dicampur secara seragam sebelum dibuat. dengan acuan mampatan panas pada 155 °C selama 60 minit. Sifat asas TPCS yang diperkukuh oleh komposit biopolimer gentian daun kelapa dikaji seterusnya untuk menilai potensinya sebagai tetulang biodegradasi. Penampilan sabut daun kelapa didapati mempunyai kesan ke atas sifat-sifat sampel. Penggabungan lilin lebah dan serat daun kelapa memperbaiki kelemahan biopolimer kanji ubi kayu, dan nisbah komposisi ialah 10 – 40 wt.%. Selain itu, ia dijangka meningkatkan sifat mekanikal. Penyelidikan ini menyiasat ujian mekanikal dengan menggunakan seperti ujian tegangan dan lentur manakala ujian haba terdiri daripada analisis termogravimetrik (TGA). Untuk ujian lain terdiri daripada Fourier Transform Infrared Spectroscopy (FTIR) dan Scanning Electron Microscopy (SEM) terhadap tingkah laku TPCS yang diperkukuh oleh komposit serat daun kelapa. Secara amnya, trend yang sama dalam ciri tegangan dan lenturan komposit gentian daun kelapa TPCS telah diperhatikan. Penambahan gentian pada 30% menunjukkan kekuatan dan modulus tegangan dan lenturan maksimum manakala terikan tegangan, didapati pada 10% menunjukkan maksimum dan bagi lenturan menunjukkan bahawa, pada 20% menunjukkan hasil maksimum. Selain itu, pencirian TPCS yang diperkukuh dengan sabut daun kelapa dilakukan dengan menggunakan SEM dan FTIR. Kehadiran ikatan kimia dalam sampel ditunjukkan oleh FTIR. Oleh itu, didapati terdapat kehadiran jalur O-H, C-H dan C-O dalam sampel. Selain itu, struktur mikro komposit ditunjukkan oleh mikrograf SEM apabila kepekatan gentian meningkat. Kehadiran pemecah gentian yang membantu dalam peningkatan sifat mekanikal. Oleh itu, dari segi terma, sifat telah diperbaiki dengan penambahan gentian, seperti yang ditunjukkan oleh kandungan sisa yang lebih tinggi. Kesimpulannya, kajian membentangkan bidang aplikasi berpotensi TPCS yang diperkukuh oleh komposit biopolimer gentian daun kelapa, terutamanya dalam aplikasi pembungkusan. Akibatnya, bahan ini berpotensi untuk menjadi pengganti yang berdaya maju untuk bioplastik tidak terbiodegradasi pada masa hadapan, dan sisa semula jadi boleh dieksploitasi sepenuhnya.

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LIST OF SYMBOLS AND ABBREVIATIONS

Ma	-	Absorbed Water
Mb	-	Bound Water
cm	-	Centimeter
cm^2	-	Centimeter Cube
cm^3	-	Centimeter Cubic
CMC	-	Ceramic Matrix Composite
CLF	-	Coconut Leaf Fiber
Td	-	Decomposition Temperature
℃	-	Degree Celsius
FTIR	-	Fourier Transform Infrared Spectroscopy.
g	-	Gram
J	-	Joule
kg	-	Kilogram
MPa	-	Mega Pascal
MMC	-	Metal Matrix Composite
µm	-	Micrometer
mg	-	Milligram
mm	-	Millimeter
SiO2	-	Nano Silica
%	-	Percentage
PVC	-	Poly (Vinyl Chloride)
PE	-	Polyethylene
PMC	-	Polymer Matrix Composite
PP	-	Polypropylene
PS	-	Polystyrene
SEM	-	Scanning Electron Microscopy
NaOH	-	Sodium Hydroxide
TGA	-	Thermogravimetric Analysis
TPPS	-	Thermoplastic Potato Starch
TPS	-	Thermoplastic Starch
Tg	-	Transition Temperature
Wt.%	-	Weight Percent
XRD	-	X Ray Diffraction

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CHAPTER 1

INTRODUCTION

1.1 Background

Environmental awareness has increased in society in recent years, involving new materials and goods. This awareness is related to creating petroleum-based products, particularly those used to produce short-life products such as disposable eating utensils, food packaging, and bags that have an indirect environmental impact (Paiva et al., 2018). Furthermore, this issue arises because of the nonrenewable waste accumulation impact. Green materials as an alternate approach without hurting the ecological environment was a solid move to address this developing problem (Jumaidin et al., 2019).

According to Ncube et al., (2020) state that, packaging is the largest and fastest-growing user of synthetic plastics. Likewise, the majority of consumer products on the market today are made of some form of plastic. Every year, nearly 280 million tons of plastic materials are produced worldwide, with most of them ending up in landfills or the oceans (Asuquo, 2018). Apart from that, the use of non-biodegradable plastic contributed to environmental issues such as water pollution, air pollution, and landfill problems (Folino et al., 2020).

All of these concerns have prompted new research. Hence, new progress in the development of biodegradable plastics, primarily from renewable natural resources, have resulted in the production of biodegradable materials with similar functionality to oil-based polymers. Increased use of bio-based materials has the potential to have a number of benefits for greenhouse gas balances and other environmental impacts over entire life cycles, as well as the use of renewable resources rather than finite resources. The use of biodegradable materials is intended to contribute to sustainability while reducing the environmental impact of disposing of oil-based polymers (Song et al., 2009).

Since starch is abundantly available, inexpensive, and biodegradable, it is regarded as one of the most promising biopolymers. Starch is a semicrystalline polymer that is the primary form of carbohydrates stored in plants. Starch is a mixture of two polysaccharides that include -D glucopyranosyl repeating units: an essentially linear carbohydrate called amylose and a highly branched polymer called amylopectin. One of the primary disadvantages of granular starch is its restricted processability, which can be enhanced with the use of plasticizers (Fekete et al., 2018).

Apart from that, according to Carvalho, (2008) state that on previous study, thermoplastic starch is semi-crystalline substance consisting of restructured starch and one or more plasticizers. Thermoplastic starch is produced by destroying starch granules in the presence of plasticizers under controlled conditions. The most extensively used plasticizers are polyols such as glycerol, glycols, and water (Fekete et al., 2018). Hence, although thermoplastic starch are biodegradable, thermoplastic starch has been found to have weak mechanical qualities, which has limited the scope of its possible applications (Jumaidin et al., 2019).

According to Pestaño & Jose (2016) found that the coconut leaf is one of the largest in the plant world. Hence, in Malaysia, coconut leaves are a readily available biomass source. Coconut shells and leaves are generated as a result of coconut's use in the food industry. Coconut leaves are high in lignin and can be used in place of wood as a source of activated carbon. Cocoanut leaves contain approximately 38.7% lignin, which is more than the lignin content of coconut sheath (29.7%).

1.2 Problem Statement

The use of non-biodegradable materials in various packaging applications has raised environmental pollution concerns (Ncube et al., 2020). Plastic are one type of waste that is placed in landfills and has negative effects on the environment. Plastic are created from nonrenewable resources such as petroleum, take hundreds of years to disintegrate, and often include pollutants that harm the environment (Adamcová et al., 2017).

In addition to enforcing environmental standards, building a product base made of biodegradable materials is necessary. Many researchers and studies have employed starch in thermoplastic starch. However, few have declared that thermoplastic starch has used in the production of biodegradable products. The biggest limitation of starch as a possible packaging material is its highly sensitive to environmental factors, particularly moisture, brittleness, and extremely poor miscibility with hydrophobic synthetic polymers. As a result, the thermoplastic starch qualities are insufficient, necessitating further research to improve thermoplastic starch qualities (Carballo et al., 2019).

Many researchers and studies have employed starch in thermoplastic starch, however few have declared that thermoplastic starch is used in the production of biodegradable products. since the qualities of thermoplastic starch are poor, more study is needed to improve the properties of thermoplastic starch (Carballo et al., 2017) .

According to Mendagri (2008) state that, coconut is one of the most popular fruits in Malaysia, with approximately 611 million coconuts consumed each year. Due to Malaysia's high consumption of coconut, a large amount of coconut waste was produced. The usage of this agricultural waste is based on the idea that it can replace the present material used in the commercial product in order to cut costs or improve the mechanical qualities of the composite material (Ganiron et al., 2017). However, the use and application of coconut leaf in industry is limited, and the leaf eventually becomes a waste (Nathanael, 1961).

According to Zheng et al., (2013) state that on previous study, since demand for coconut products has grown in recent years, the scale of coconut agriculture has grown, resulting in a significant amount of waste from the growing and processing of coconut. These wastes are thrown or burned immediately, not only harming the natural environment but also wasting a large amount of resources.Thus, learning and understanding the complete usage of coconut leaf waste, as well as analysing existing challenges, is important in supporting the development of comprehensive usage procedures for coconut leaf waste. The overproduction of coconut leaf need to be fully utilize as some part of the coconut plant can be used as coconut fiber especially coconut leaf in produce composite materials.

This study aims to to develop biodegradable packaging from coconut leaf fiber and thermoplastic starch by investigating the thermal and mechanical properties of the material. Aside from that, in this study aim to develop a material that positively impacts the environment and creates a superior material substitute for petroleum-based products. This research will provide information on coconut leaf fiber, allowing overproduction of coconut leaves used as new biodegradable material.

1.3 Objective of Study

The main objectives of this research and study are as follows :

a) To produce biodegrable thermoplastic cassava starch reinforced with coconut leaf fiber composite.

b) To investigate the thermal and mechanical properties of biodegradable thermoplastic cassava starch reinforced with coconut leaf fiber composite.

c) To produce biodegradable packaging from the coconut leaf fiber.

1.4 Significance of Study

The justification of this study are as follows:

1.4.1 The outcomes of the recent study might deliver a new information regarding to the biodegradable thermoplastic cassava starch/beeswax reinforced with coconut leaf fiber composite.

1.4.2 The problem related to the environmental pollution might be reduced by applying the fully bio-composite material started from coconut leaf fiber and thermoplastic cassava starch/beeswax.

1.4.3 The problem caused by the conventional thermoplastic also can be diminished by introducing the new material from cassava starch and coconut leaf.

1.4.4 More value added to the existence of coconut leaf fiber by implemented it as new reinforcement material in producing bio-composite product.

1.5 Scope of Study

The primary raw materials used in this study are cassava starch, coconut leaf fiber, beeswax, and glycerol. The thermoplastic cassava starch mixture formed by combining cassava starch with glycerol at the appropriate percentage of formulation. In this study, glycerol serves as a plasticizer. In the appropriate percentage of formulation, beeswax is added to a mixture of cassava starch and glycerol. Then, due to the percentage required for this study, coconut leaf fiber is added as reinforcement to the mixture of three raw materials. The Hot press machine method was used to create the thermoplastic starch composite with beeswax reinforcement and coconut leaf fiber. In thermal testing, the machine that will be used are thermogravimetric Analysis. For mechanical testing are Tensile Test, and Flexural Test while for other testing Fourier Transform Infrared (FTIR),