FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

EFFECT OF SUGARCANE FIBRE ON THE MORPHOLOGICAL AND MECHANICAL PROPERTIES OF THERMOPLASTIC POTATO STARCH

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS) WITH HONOURS

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APPROVAL

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

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Date	:	18 January 2019

DEDICATION

To my beloved father and mother

ABSTRACT

Nowadays, the needs to develop more environmentally friendly products are increasing due to the non-biodegradable accumulated waste on this planet. Hence, various types of eco-friendly materials have been developed to address this problems. The biopolymer obtained from renewable sources in an attractive alternative material to replace the petroleum-based polymer. This is because these alternative materials are easily biodegradable and are more environmentally friendly than conventional polymers. Starch is one of the most widely used biopolymers because of its low cost, readily available, and abundant in natural, renewable, and environmentally-friendly resources. The aim of this study is to investigate the characteristic of biodegradable thermoplastic potato starch reinforced with sugarcane fibre in the range of 1 to 15 wt.%. Potato starch was firstly pre-mixed with glycerol as the plasticizers. The weight ratio of potato starch and glycerol was maintained at 80:20. The mixture was blend using high speed mixer at 3000rpm before poured into the mould. The thermoplastic were then hot pressed at 145°C for 60 minute. The thermoplastic potato starch/sugarcane fibre were characterized for their mechanical and morphological properties. The mechanical behaviour of TPPS/sugarcane fibre was conducted through tensile, flexural and impact testing. The morphology of TPPS/sugarcane fibre was investigated by using scanning electron microscope (SEM). Incorporation sugarcane fibre from 1 to 15 wt.% has significantly improved the tensile, flexural and impact properties of thermoplastic potato starch. The improvement in the tensile, flexural and impact properties of the composites were evidence after incorporation of sugarcane fibre. The tensile and flexural properties shows that the tensile strength and modulus of the composite increase from TPPS matrix until 15 wt.% of the fibre contain. From the tensile strength result, it is shows 202.7% improvement when TPPS reinforced with the sugarcane fibre, while the tensile modulus have 265.2% improvement for TPPS composite. Other than that, the flexural strength shows that 198% improvement and the flexural modulus 261.7% improvement for the TPPS composite. Overall, the findings from this study demonstrated that thermoplastic potato starch (TPPS) reinforced with sugarcane fibre has shown improved functional characteristic than the origin material. In conclusion, the TPPS reinforced sugarcane fibre composites are potential alternative material for biodegradable product such as biodegradable plastic packaging.

ABSTRAK

Pada masa kini, keperluan untuk membangunkan produck meesra alam semakin meningkat disebabkan oleh sisa terkumpul yang tidak terbiodegradasi di planet ini. Oleh itu, pelbagai jenis bahan mesra alam telah dibangunkan untuk menangani masalah ini. Biopolimer yang diperolehi daripada sumber juga boleh diperbaharui dalam bahan alternatif yang menarik untuk menggantikan polimer berasaskan petroleum. Ini kenerana bahan alternatif ini mudah terbiodegradasi dan lebih mesra alam daripada polimer konvensional. Kanji adalah salah satu bahan daripada biopolimer yang paling banyak digunakan kerana kosnya yang rendah, mudah didapati, dan banyak sumber semulajadi, boleh diperbaharui, dan mesra alam. Tujuan kajian ini adalah untuk mengkaji sifat termoplastik kanji kentang biodegradasi yang diperkuat dengan serat terbut dalam julat 1 hingga 15% berat. Pertama kali, kanji kentang dicapur dengan gliserol sebagai pelapis. Nisbah berat kanji kentang dan gliserol dikekalkan pada 80:20. Campuran ini dicampur menggunakan pengadun kelajuan tinngi pada 3000 rpm sebelum dituangkan ke dalam acuan. Termoplastik kemudian ditekan pada suhu 145°C selama 60 minit. Termoplastik kanji kentang/serat tebu dicirikan untuk sifat mekanik dan morfologi mereka. Ciri-ciri mekanikal TPPS/serat tebu dijalankan melalui ujian tegangan, ujian lenturan dan sifat-sifat kesan. Morfologi TPPS/serat tebu diselidiki dengan menggunakan pengimbas mikroskop elektron (SEM). Penggabungan serat tebu dari 1 hingga 15% berat telah meningkatkan ketegangan, lenturan dan kesan-kesan termoplastik kanji kentang. Peningkatan sifat tegangan, lenturan dan kesan komposit adalah keterangan selepas penambahan serat tebu. Ciri-ciri tegangan dan lenturan menunjukkan bahawa kekuatan tegangan dan modulus peningkatan komposit daripada matrik TPPS sehingga 15% berat yang mengandungi serat. Dari hasil kekuatan tegangan, menunjukkan peningkatan sebanyak 202.7% apabila TPPS diperkuat dengan serat tebu, ,manakala modulus tegangan mempunyai peningkatan 265.2% untuk komposit TPPS. Selain itu, kekuatan lenturan menunjukkan bahawa peningkatan sebanyak 198% dan modulus lenturan sebanyak 261.7% peningkatan untuk komposit TPPS. Secara keseluruhannya, penemuan kajian ini menunjukkan bahawa termoplastik kanji kentang (TPPS) yang diperkuat dengan serat tebu telah menunjukkan ciri-ciri berfungsi yang lebih baik daripada bahan asalnya. Kesimpulannya, TPPS komposit yang diperkuat dengan serat tebu adalah bahan alternatif yang berpotensi untuk produk biodegradasi seperti plastik pembungkusan bidegradasi.

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LIST OF ABBREVIATIONS

AC	Alternative Current
As	Arsenic
ASTM	American Society for Testing and Materials
CI	Complexing index
Cl	Chloride
CS	Cassava Starch
Cu	Copper
Fe	Iron
HCl	Hydrogen chloride
HCHO	Aldehydes
HMI	Human Machine Interface
HT	Heat Treatment
i.e / e.g	For example
LDPE	Low-density Polyethylene
Max	Maximum
Min	Minimum
ML	Machine Learning
MPa	Mega Pascal
NH_4	Ammonium
Ni	Nickel
Pb	Heavy metals / Lead
PBAT	Poly (butylene adipate-co-terephthalate)
PE	Polyethylene
PLA	Poly (lactic acid)
PLC	Programmable Logic Controller
PP	Polypropylene
PS	Potato Starch
SEM	Scanning Electron Microscopy
SPS	Sugar palm starch
SO_2	Sulphur dioxide

SO_4	Sulphate
Temp.	Temperature
TPS	Thermoplastic Starch
TPCS	Thermoplastic Corn Starch
TPPS	Thermoplastic Potato Starch
TPRS	Thermoplastic Rice Starch
TPSA	Thermoplastic Sugar Palm Starch/Agar
UHMWPE	Ultra-High Molecular Weight Polyethylene
wt	Weight
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Background

In recent, the requirements to grow more ecological inviting product is expanding because of the gathering of non-biodegradable waste on the land fill. Henceforth, different sort of "green" materials were produced so as to handle this issues. Biopolymer derived from inexhaustible assets is a promising elective material for petroleum based polymer since it is promptly biodegradable and this way, more ecological cordial than the customary polymers. In that time, polymers have risen as feasible other options to some customary materials, for example, metals, because of their inalienable properties like ease in fabrication, basic control, productivity and efficiency, simple accessibility, less physical work, and cost reduction (V K Thakur et al.,2014). Different sort of regular assets were utilized to create biopolymer going from lipid, protein, cellulose, and starch. Among these sources, starch is considered as the most encouraging asset because of a few characteristic, for example, ease, inexhaustible, and absolutely biodegradable (Jumaidin et al., 2017b). Underneath the nearness of heat and plasticizer, starch may be can changed over into thermoplastic starch (TPS) which has comparable process capacity with the customary thermoplastic. The thermo plasticity of this biopolymer of this biopolymer is the principle points of interest for the preparing of this material. This empowers this biopolymer to be handled by utilizing the ordinary preparing gear utilized for manufactured thermoplastic, for example, extruder, injection moulding, and compression moulding (Haque, 2017).

In general, the properties of natural fibres vary depending on their species, growing conditions, geological area, method of fibre preparations and many other factors (M. L.

Sanyang et al., 2016) (M. L. Sanyang et al., 2016). Many type of natural fibre can be used as a reinforcement to fabricate the composite. The examples of natural fibre that can be used to fabricate the composite such as sugarcane, sugar palm, chitosan, sisal, kenaf and etc. TPS likewise has a few detriments, for example, poor mechanical strength and water resistance, which its potential application (Jumaidin et al., 2017b) and the fibres are broadly as part of polymeric materials to enhance mechanical properties (Yu et al., 2006). Furthermore, fuse of regular material as the support in polymer composites has made more ecological agreeable qualities to the composites. Also this green methodologist diminish the reliance of the manufacturing industry to the synthetic materials, for example, glass fibre which regularly identified with high potential of hazard for the manufacturing workers. The improvement of more ecological cordial materials gives another point of view to the manufacturing industry which is regularly identified with the natural contamination for both the creation and transfer of the manufactured polymer.

1.2 Problem Statement

High utilization of petroleum based polymer by the general public has created serious environmental issues mainly during the disposal stage. These wastes are not promptly biodegradable when arranged into nature such as land or ocean which conveyed major issues to the general public, wildlife, and condition also. In addition, air pollution is another concerning issue following the burning of this wastes. The chemical from the synthetic polymer can cause the illness to humans and maybe harmful to the bodies. Other than that, the effects of using synthetic polymer can cause life on land, as well as on the sea dead. This is because, plastic synthetic cannot be disposed and it make it floated on the surface of the water. Accumulation of petroleum based plastic wastes has created serious environmental issues since they are not promptly biodegradable nor inexhaustible. In later, numerous

nations have prohibited the utilization of plastic sack as an exertion for taking care of this issue.

Malaysia as a tropical country that has ample resources of natural fibre. One of those abundant natural fibres found in Malaysia is sugarcane fibre but has not been widely used as reinforcement in the fabrication of polymer composites. Sugarcane is one of the primary harvests utilized as a part of the generation of sugar: 70% of the world's sugar is produced using sugarcane and the staying 30% originates from the sugar beet trim. Nonetheless, this isn't the situation for the sugarcane developed in India which happens to be the second biggest maker of sugarcane, after Brazil. Starch separated from sugarcane fibre maybe changed into thermoplastic material within the sight of warmth and plasticizer which results to an unbending material. In any case, the perfect thermoplastic starch (TPS) has detriment that utmost its utilization in business plastic industry, for example, the poor mechanical quality (Jumaidin et al., 2017b). Hence, legitimate alterations ought to be utilized keeping in mind the end goal to enhance the properties of this material. The potential changes incorporate mixing with different polymers and fortifying with normal filler and fibre.

For the project justification, this study aims to encourage the development of biodegradable materials form the renewable resources to substitute conventional non-biodegradables materials in any applications in a low cost and effective manners. According to Bergel et al., (2017), they said that a few petroleum based plastic packaging are difficult to recycling and it have superior in price. Therefore, the importance of creating materials from the thermoplastic starch is to save the cost of raw materials and easily dispose of them. In addition, the purpose of fabricate the thermoplastic starch is to develop environmentally friendly materials, easy to remove on a short shelf life according to the creation of green technology.

1.3 Research Objective

The vital point of this investigation is to create and describe absolutely inexhaustible and biodegradable materials in light of characteristic assets. The particular goals are:

1. To develop thermoplastic potato starch as a matrix reinforced to the sugarcane fibre.
2. To determine the effect of sugarcane fibre on the mechanical properties of thermoplastic potato starch.
3. To investigate the effect of sugarcane fibre on the morphology of the composites.

1.4 Significance of Study

1. The discoveries from the present investigation are expected to improve the learning in creating biodegradable polymer from thermoplastic potato starch and sugarcane fibre.
2. The development of biodegradable polymer with upgraded properties in this study is expected to help in tending to the natural issues in regards to the elective materials for petroleum based polymer.
3. The issues related with petroleum based polymer, for example, natural contamination amid the generation and transfer can be lightened by utilizing a completely biodegradable and inexhaustible polymer composites got from sugarcane fibre, and thermoplastic potato starch.
4. In terms of waste management, this investigation has investigated another potential utilization of sugarcane squanders from the bagasse extraction as novel support for biopolymer composites.

5. Besides, this examination likewise uses the sugarcane tree for yielding starch and fibre for the advancement of the composites. Consequently, included more an incentive for the sugarcane tree other than creating the sugar.

6. For the commercialization relevancy, this material composite has a high potential to be used especially in a packaging for short life product and biodegradable.

1.5 Scope of Study

In this examination, the sugarcane fibre extract from the sugarcane plant utilized as the based material for the advancement of thermoplastic potato starch. Thermoplastic potato starch was develop by utilizing glycerol as the plasticizer. Characterizations of their mechanical properties were performed using tensile test, flexural test, and impact test. The morphology of TPPS/sugarcane fibre was investigated by scanning electron microscopy (SEM). The relevant application for the composites developed in this study is a short-life product. Therefore, the potential application of the composites as biodegradable product i.e disposable tray was evaluated through comparison on the primary characteristics against the conventional material and the current thermoplastic starch.

1.6 Structure of Thesis

This thesis represent the introduction, literature review, methodology and preliminary result about the development of biopolymer composites by using sugarcane fibre as the reinforcement material and potato starch as the matrix.

Chapter 1

The problem that initiate this research and the research objectives highlighted in this chapter. The scope of thesis were also elaborated in this chapter and the significance of this study.

Chapter 2

This chapter presents a literature review and study the journal that related to the topic of this thesis. Moreover, the research gap obtained from the review were also clarified within the chapter.

Chapter 3

This chapter presents the methodology utilized in this experiment and it is showed the preparation of the materials, testing procedure and data collection.

Chapter 4

This chapter presents the result and discussion about the tensile properties, flexural properties, impact strength, and morphological properties investigated by SEM of TPPS composites.

Chapter 5

This chapter presents the overall conclusions from the whole study and experiment as well as future recommendations for further improvement of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Due to environment and manageability issues, this century has seen exceptional accomplishments in green innovation in the field of material science through the improvement of bio-composites (Joshi et al., 2004). The expanding familiarity with society to the significance of ecological safeguarding has driven tremendous measure of explores towards the advancement of more natural inviting materials. The advancement of elite materials produce using normal assets is around the world. In later, the advancement of regular fibre composites is getting more genuine consideration because of the promising properties of this material as an option for the ordinary materials. The plenteous of horticultural waste gives an ease source to the improvement of this material. Furthermore, the improvement of bio-based polymer as the alternatives matrix for the petroleum-derived polymer gives another and green point of view for the composites Common synthesis / Bio-fibre (Bio-composites) show up as a reasonable contrasting particularly in automotive, food packaging, infrastructure, and building item application (Scholten et al., 2014). Among the biopolymer, starch is a standout amongst the most encouraging because of the simple accessibility, ease, copious in nature, sustainable and biodegradable.