PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE REINFORCED WITH SUGAR PALM FIBER FILAMENT

NUR AQILAH BINTI AHMAD SOBERI

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY WITH HONOURS

2022

Faculty of Mechanical and Manufacturing Engineering Technology

PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE REINFORCED WITH SUGAR PALM FIBER FILAMENT

Nur Aqilah Binti Ahmad Soberi

Bachelor of Manufacturing Engineering Technology with Honours

2022

PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE REINFORCED WITH SUGAR PALM FIBER FILAMENT

NUR AQILAH BINTI AHMAD SOBERI

A thesis submitted
in fulfillment of the requirements of Bachelor of Manufacturing Engineering Technology with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this thesis entitled "Physical, Mechanical and Morphological Properties of Recycled Polypropylene Reinforced With Sugar Palm Fiber Filament" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	Nur Aqilah Binti Ahmad Soberi
Date	:	17.01.2022

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 degree of Bachelor of Manufacturing Engineering Technology with Honours.

Signature	:	
Supervisor Name	:	Dr. Nuzaimah Binti Mustafa
Date	:	18 January 2022

DR. NUZAIMAH BINTI MUSTAFA
Pensyarah
Jabatan Teknologi Kejuruteraan Pembuatan
Fakulti Teknologi Kejuruteraan
Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

DEDICATION

This study is specially dedicated to my beloved parents, who have given the strength that I deserved when I thought of giving up, always providing their moral, spiritual, emotional and financial support.

Not to forget my sibling, sister and brother, relatives, academic advisor and supervisor Dr. Nuzaimah Binti Mustafa, friends and classmates who shared their words of advice and encouragement to finish this study.

Last but not least, I dedicated this book to The Almighty "Allah", thank you for the guidance, strength, power of mind, protection, skills and for giving a healthy life.

ABSTRACT

Presently, polypropylene (PP) is plastic-based material that being widely used for commercial and household purposes along with polyethylene terephthalate (PET) and other thermoplastic material. The development of biodegradable polymer from recycling resources has been promoted by increasing environmental awareness to replace conventional non-biodegradable polymer in various applications. PP is one of the most affordable plastics available today, and it is used both as a plastic and a fiber in sectors such as automotive manufacturing, furniture assembly, and the aerospace sector. PP offers several benefits such as low cost, high melting point, sustainable and most important thing is, it is 100% recyclable. However, PP has become a major threat to the environment due to its non-degradable property. There are certain benefits of using natural fibers as reinforcement in 3D printing filament due to the rapid demand for renewable, cost-effective, and eco-friendly materials in many applications. The addition of natural fiber to polymer composites as reinforcement has created more “green” composites and can replaced conventional glass fiber and other synthetic fiber composites that possess manufacturing hazard. As a natural fiber, SPF is the key component that become one of the element for reinforment polymer composites. Sugar palm fiber (SPF) was extracted from sugar palm tree (*Arenga Pinnata*) which were usually found in Southeast Asia like Malaysia and Indonesia. In this study, SPF was successfully treated by alkaline treatment using 6% of sodium hydroxide solution (NaOH). The investigations of thermal properties were then carried out by using thermogravimetry analysis (TGA) and diffraction scanning calorimetry (DSC). The fabrication of 3D printing filament using twin screw extruder machine by inserting different amount of sugar palm fiber loading (0%, 1%, 3%, 5%) into the polymer matrix as reinforcement to find the characteristic of their physical and environmental properties. A few tests have been done to analyze the physical, mechanical, and morphological properties of the filament. Overall, recycled polypropylene reinforced with sugar palm fiber are potential alternative to develop a new 3D printing filament material.

ABSTRAK

Pada masa ini, polipropilena (PP) adalah bahan berasaskan plastik yang digunakan secara meluas untuk tujuan komersial dan isi rumah bersama dengan polietilena tereftalat (PET) dan bahan termoplastik lain. Pembangunan polimer terbiodegradasi daripada sumber kitar semula telah digalakkan dengan meningkatkan kesedaran terhadap alam sekitar untuk menggantikan polimer tidak terbiodegradasi konvensional dalam pelbagai aplikasi. PP adalah salah satu plastik yang paling berpatutan yang ada sekarang, dan ia digunakan sebagai plastik dan gentian dalam sektor seperti pembuatan automotif, pemasangan perabot, dan sektor aeroangkasa. PP menawarkan beberapa faedah seperti kos rendah, takat lebur yang tinggi, mampan dan yang paling penting ialah, ia 100% dapat dikitar semula. Walau bagaimanapun, PP telah menjadi ancaman besar terhadap alam sekitar kerana harta benda yang tidak boleh terurai. Terdapat faedah tertentu menggunakan gentian semula jadi sebagai penguat dalam filamen percetakan 3D kerana permintaan yang cepat untuk bahan yang boleh diperbaharui, menjimatkan kos, dan mesra alam dalam banyak aplikasi. Penambahan gentian semula jadi untuk komposit polimer sebagai tetulang telah menghasilkan lebih banyak komposit "hijau" dan dapat menggantikan gentian kaca konvensional dan komposit gentian sintetik lain yang mempunyai bahaya pembuatan. Sebagai gentian semula jadi, SPF adalah komponen utama yang menjadi salah satu elemen untuk komposit polimer pengukuhan. Serat kelapa sawit (SPF) diekstrak daripada pokok kelapa sawit (Arenga Pinnata) yang biasanya terdapat di Asia Tenggara seperti Malaysia dan Indonesia. Dalam kajian ini, SPF telah berjaya dirawat dengan rawatan alkali menggunakan 6% larutan natrium hidroksida (NaOH). Penyiasatan sifat terma kemudiannya dijalankan dengan menggunakan analisis termogravimetri (TGA) dan kalorimetri pengimbasan difraksi (DSC). Fabrikasi filamen cetakan 3D menggunakan mesin penyemperit skru berkembar dengan memasukkan jumlah muatan serat kelapa sawit yang berlainan (0%, 1%, 3%, 5%) ke dalam matriks polimer sebagai tetulang untuk mencari ciri sifat fizikal dan persekitaran mereka. Beberapa ujian telah dilakukan untuk menganalisis sifat fizikal, mekanikal dan morfologi filamen. Secara keseluruhan, polipropilena kitar semula yang diperkuat dengan serat kelapa sawit adalah alternatif yang berpotensi untuk menghasilkan bahan filamen percetakan 3D baharu.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

Firstly, I like to express my gratitude to my supervisor Dr Nuzaimah Bte Mustafa for trust me in doing this project as my final year project. She who guides me and helps me throughout the process to complete this thesis writing and research of project. Without her support and encouragement throughout this project it will be difficult for me to complete this project successfully. I also want to thank my group members Muhammad Zulqarnain Amin bin Razali, Muhammad Arief Izuddin bin Abdul Ghapar and Muhammad Khairul Amin for giving the full cooperation and the valuable comments to complete this project Finally, I would like to express my gratitude to my parents Rokiah Binti Abdul Rahman for full support and encourage me to be more patient in making this project without them it will be impossible to accomplish this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

PP	-	Polypropylene
SPF	-	Sugar Palm Fiber
PET	-	Polyethylene Terephthalate
3D	-	Three-dimensional
(1)	-	Formula
TPU	-	Thermoplastic Polyurethane
TGA	-	Thermogravimetric Analysis
SEM	-	Scanning Electron Microscopy
HIPS	-	High Impact Polystyrene
ABS	-	Acrylinitrile Butadiene Styrene
AM	-	Additive Manufacturing
FDM	-	Fused Deposition Modeling
PLA	-	Polylactic Acid
PVA	-	Polyvinyl Alcohol
PC	-	Polycarbonate
MgO	-	Magnesium Oxide
Al_2O_3	-	Aluminium Oxide
H_3PO_4	-	Phosphoric Acid
PS	-	Polystyrene
HDPE	-	High Density Polyethylene
LDPE	-	Low Density Polyethylene
PVC	-	Polyvinyl Chloride
NaOH	-	Sodium Hydroxide
N_2	-	Natrium gas

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background Study

Presently, polypropylene (PP) is plastic-based material that being widely used for commercial and household purposes along with polyethylene terephthalate (PET) and other thermoplastic material. PP is one of the most affordable plastics available today, and it is used both as a plastic and a fiber in sectors such as automotive manufacturing, furniture assembly, and the aerospace sector. However, PP has become a major threat to the environment due to its non-degradable property. The development of biodegradable polymer from recycling resources has been promoted by increasing environmental awareness to restore conventional non-biodegradable polymer in various applications (Mendes et al., 2016).

PP offers several benefits such as low cost, high melting point, sustainable and most important thing is, it is 100% recyclable. Some research have been done using recycled material such as recycled polypropylene reinforced with natural fiber composite to overcome this issue. There have certain interest of using natural fibers as reinforcement in 3D printing filament because there is a growing need for sustainable, save cost, and environment benign resources in a spectrum of uses. Natural fibers were developed with the aim of making lighter composites at cheaper prices than composite material reinforced polymer materials that already exist (Akil et al., 2011). Therefore, petroleum-based materials, such as PP and PET, are used comprehensively with natural fibers, such as sugar palm fiber, palm oil fiber, jute, hemp, and wood dust.

The addition of composites of organic materials and thermoplastics as reinforcement has created more “green” composites and can replaced conventional glass fiber and other synthetic fiber composites that possess manufacturing hazard. This is the effective way to solve environmental issue for waste problem, and production of non-degradable material with the development of environmental friendly material and matrix such as recycled polypropylene reinforced with sugar palm fiber.

1.2 Problem Statement

The petroleum-based polymer has created a major environmental issues, especially during the disposal stage because of the widespread use by the global society. Global waste production is currently around 1.3 billion tonnes per year, with estimates of 2.2 billion tonnes by 2021 (Khosravani & Reinicke, 2020). In addition, many countries like China have banned plastic bags that can caused many ecological and environmental issue. For example, the most issue caused by plastic bag is the amount of plastic waste produced. Moreover, the most common material used in development of 3D printing filament such as ABS (Acrylonitrile Butadiene Styrene) are one of the factor that can cause environmental issue where it is a hazardous, non-biodegradable substance that, when heated, emits pollutant substances with an unpleasant odour. This shows that 3D printing produced lots of plastic waste to the environment. Hence, to overcome this problem, non-biodegradable polymer need to be replaced with renewable natural sources.

PP is one of the most commonly used thermoplastic material along with PET that can be found in 3D printing filament. It is a biodegradable plastic material that is widely employed in a variety of goods. According to LeBlanc, (2016), because of its melting temperature and hardness, PP is the highest widely used plastic bottles product in the United States, with nearly £5 billion manufactured in 2010. Unfortunately, this will cause the vast majority of these thermoplastic end up as plastic waste in landfills, because of its short lifespan. Moreover, plastic waste in disposal area, PP-based products decompose gradually, taking 20-30 years to totally dissolve. A proper change should be made by recycling this plastic so that it can reduce more waste in landfills and also the properties of PP can be improved. Therefore, it is the most environment conscious and save cost strategy to deal with this issue.

Sugar palm fiber (SPF) was extracted from sugar palm tree (*Arenga Pinnata*) which were usually found in Southeast Asia like Malaysia and Indonesia. There are several parts from sugar palm tree like the fibers, the trunk, the root, its leaves, sap from flowers, and its fruits which can utilize for making many useful products. For example, the fiber from sugar palm tree are suitable for usage as reinforcement material in the making of 3D printing filament. However, SPF has not yet frequently used as reinforcing in the manufacturing of composite materials (Sanyang et al., 2016). This is because the local people did not have enough exposure on 3D printing. They usually utilized the fiber to make brooms, brushes, ropes, door mat, and etc. As a natural fiber, SPF is the key component that become one of the element for reinforment polymer composites.

The project justification of this study is to develop 3D printing filament material using recycled PP reinforced SPF which comes from natural resources to solve the problem of an environmental issue and develop biodegradable polymer. Secondly, to characterize the physical and environmental properties whether the recycled polypropylene and sugar palm fiber substance that is completely recyclable and may be properly rid off in the surroundings.

1.3 Research Objective

The aim of this research is to develop the 3D filament material from recycled polypropylene reinforced with sugar palm fiber. Hence, the objectives are as follows:

a) To characterize the physical and thermal properties of sugar palm fiber and recycled polypropylene.

b) To evaluate the effect of sodium hydroxide treatment on the sugar palm fiber thermal properties.

c) To analyze the physical, mechanical and morphological properties of recycled polypropylene composite reinforced with sugar palm fiber.

1.4 Scope of Research

In this study, recycled polypropylene was used as the primary material. Recycled polypropylene was developed from recycled factory in the form of pellets. The physical properties of recycled PP will be tested by using TGA and DSC. Then, sugar palm fiber was added as reinforcement into recycled polypropylene to produced 3D printing filament material. The modification of recycled polypropylene reinforced with sugar palm fiber was performed by inserting different amount of sugar palm fiber loading (0%, 1%, 3%, 5%) into the polymer matrix to find the characteristic of their physical, mechanical and morphological properties. The fabrication process will be using twin screw extruder to form 3D printing filament. Therefore, the application of the reinforcement of sugar palm fiber with recycled polypropylene to develop 3D filament material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the industry field, the words “plastic” and “polymer” are often used interchangeably. Plastics are actually chains of molecules linked together which these chains can form into polymers. Plastics may be shaped, stretched, cast, and blasted into virtually any form, sheet, or foam, and they can even be made into textile threads. Over the years, additive manufacturing (AM) which also known as 3D printing is becoming more popular, and new developments are being launched all the time. 3D printing is the technique of layering materials to create a three-dimensional object. In the AM process, there are lots of materials that have been used and they are pure polymers, polymer matrix composites, polymer ceramic composites, nanocomposites, and fiber-reinforced composites. These materials have their own specialties and important factors such as material type, texture, cost, etc. However, plastic waste product from petroleum-based is quite pricey and difficult to recycled. This issue should be solved by producing a biodegradable product made from renewable materials such as recycled polypropylene.

2.2 3D printing in general

After 30 years of 3D printing was invented, additive manufacturing (AM) has progressively outgrown its specialty uses and is helping develop a wide range of manufacturing methods. AM is utilized in a variety of manufacturing industries, including automotive, biomedical, and aerospace. AM is categorized as a multistep process, or a single step process derived by ISO/ASTM 52900. Binder jetting, directed energy deposition,