PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE(PP) REINFORCED WITH WOOD DUST FILAMENT

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BACHELOR OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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in fulfilment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE(PP) REINFORCED WITH WOOD DUST 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 : Zulqarnain

Name : Muhamad Zulqarnain Amin Bin Razali

Date : 27 January 2022

APPROVAL

I hereby declare that I have checked this report entitled "PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE(PP) REINFORCED WITH WOOD DUST FILAMENT" and in my opinion, this thesis it complies the partial fulfilment for awarding the award of the degree of Bachelor of Mechanical and Manufacturing Engineering Technology with Honours.

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DEDICATION

This report is dedicated to my parents, lecturers, and friends for their endless support and encouragement. And a very big thank you to my supervisor, Dr. Nuzaimah Binti Mustafa who has guided me from zero along way to finish my project. Thank you all for your endless support, and courage for me to finish this project.

ABSTRACT

In recent years, the usage of natural fibre composites has gained significant interest due to their low density, high availability, and low cost. Due to the environment factor which is to reduce waste which can affect the ecosystem, for example, the plastic waste which take a long time to decompose were recycled to produce a material that can be reused. An investigation into the development of sustainable natural fibre filaments based on wood dust and recycled polypropylene and the effect of fibre weight ratio on thermal, mechanical, and morphological properties of natural fibre filaments are being conducted in this study. The abilities of combination between wood dust and recycled polypropylene as new composite material will be evaluated whether it is suitable to be used in the 3D printing field as a composite filament. Different ratios were used in this study which is 0%, 1%,3% and 5%. The wood dust fibre also will be treated using 6% sodium hydroxide (NaOH) and the soaking time was 2 hours to enhance the compatibility of the fibre and matrix. Both of material was analyse using TGA to analyse the degradation of wood fibre and recycled polypropylene by monitoring weight changes. The melting point and melt flow rate were analyse using Differential scanning calorimetry (DSC) analysis for fabrication process purpose. By using twin screw extruder machine, both of material were mixed and extruded to produce 3D printing filaments. A few tests have been done to study the mechanical characteristic which by using tensile test to measure the tensile strength of the filaments. Physical characteristic of the filaments was measure using water absorption method where the weight, length and diameter of the filaments were measured and the physical change of the filament after soaked for 48 hours has been recorded. The last test that has been analyse was on the morphological analysis where the filament cross section was observe using SEM. The data that were obtained from the test has been recorded and analysed.

ABSTRAK

Dalam beberapa tahun kebelakangan ini, penggunaan komposit gentian asli telah mendapat minat yang ketara kerana ketumpatannya yang rendah, ketersediaan yang tinggi dan kos yang rendah. Disebabkan faktor persekitaran iaitu mengurangkan bahan buangan yang boleh menjejaskan ekosistem contohnya, sisa plastik yang mengambil masa yang lama untuk mereput telah dikitar semula untuk menghasilkan bahan yang boleh digunakan semula. Satu penyiasatan ke atas pembangunan filamen gentian asli lestari berasaskan habuk kayu dan polipropilena kitar semula dan kesan nisbah berat gentian ke atas sifat terma, mekanikal dan morfologi filamen gentian asli sedang dijalankan dalam kajian ini. Kebolehan gabungan antara habuk kayu dan polipropilena kitar semula sebagai bahan komposit baharu akan dinilai sama ada ia sesuai digunakan dalam bidang percetakan 3D sebagai filamen komposit. Nisbah yang berbeza digunakan dalam kajian ini iaitu 0%, 1%,3% dan 5%. Gentian habuk kayu juga akan dirawat menggunakan 6% natrium hidroksida (NaOH) dan masa rendaman adalah 2 jam untuk meningkatkan keserasian gentian dan matriks. Kedua-dua bahan dianalisis menggunakan TGA untuk menganalisis degradasi gentian kayu dan polipropilena kitar semula dengan memantau perubahan berat. Takat lebur dan kadar aliran cair dianalisis menggunakan analisis kalorimetri pengimbasan Berbeza (DSC) untuk tujuan proses fabrikasi. Dengan menggunakan mesin penyemperit skru berkembar, kedua-dua bahan dicampur dan disemperit untuk menghasilkan filamen cetakan 3D. Beberapa ujian telah dilakukan untuk mengkaji ciri mekanikal dengan menggunakan ujian tegangan untuk mengukur kekuatan tegangan filamen. Ciri fizikal filamen diukur menggunakan kaedah penyerapan air di mana berat, panjang dan diameter filamen diukur dan perubahan fizikal filamen selepas direndam selama 48 jam telah direkodkan. Ujian terakhir yang telah dianalisis ialah analisis morfologi di mana keratan rentas filamen dicerap menggunakan SEM. Data yang diperoleh daripada ujian telah direkodkan dan dianalisis

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

MM	-	Millimetre
AM	-	Additive manufacturing
PP	-	Polypropylene
PLA	-	Polylactic acid
ABS	-	Acrylonitrile Butadiene Styrene
FDM	-	Fused Deposition Modelling
SLA	-	Stereolithography Apparatus
EBM	-	Electron Beam Melting
LOM	-	Laminated Object Manufacturing
SLS	-	Selective Laser Sintering
DLP	-	Digital light projection
NaOH	-	Sodium Hydroxide
PET	-	Polyethylene terephthalate
TGA	-	Thermogravimetric analysis
°C	-	Degree Celsius
FSG	-	Fibre sugar cane bagasse
HDPE	-	High Density Polyethylene
FTIR	-	Fourier-transform infrared spectroscopy
DSC	-	Differential Scanning Calorimeters
SEM	-	Scanning Electron Microscope

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Producing a new product nowadays was a necessary to increase production for global marketing purpose. This production process was aligning with the development of new high technology for manufacturing purpose. 3D printing machine or additive manufacturing method was one of new high technology of production machine that has been developed by the people especially on industrial sector who deal with design and production manufacts. Starting with designing the product that we want to produce using a selected software such as solid work or the others, then the design will be converted into a specific code so that the code will be indicator for the machine to print out the product that we have been design.

Polypropylene (PP) is the first stereoregular polymer to have reached industrial importance. It is a thermoplastic, meaning that it becomes pliable or moldable at a certain elevated temperature and solidifies upon cooling. Polypropylene is processed into film for packaging and into fibers for carpets and clothing. PP belongs to the group of polyolefins and is partially crystalline and non-polar. It has similar properties as polyethylene, but it is harder and more heat resistant. It is a white rugged material with a high chemical resistance. Poly propylene is the second-most widely produced commodity plastic (after polyethylene) and it is often used for product packaging and labeling.

In other side, another recycled waste that can be highlighted in this project was natural fibre material which is the wood dust. Now days, this natural fiber material become one of wasted that people reused to prevent dumping of such material on the earth's surface.

Wood dust also has its own commercial value. Many studies have been done to identify the potential of this material for other uses especially in aspect of waste recycling. With the high value of strength and other physical and mechanical properties, this wood dust will be one of importance material in this research and product development.

By implementing a combination of recycling waste which is wood dust with the recycled plastic material (Polypropylene), a new type of recycling filaments will be represented to be used as a filament that has low cost and high quality. By using the recycling filaments also can reduce waste of material such as wood dust. Wood dust is a bio filler that can be obtain easily as it an abundant material (Kariz et al., 2018).

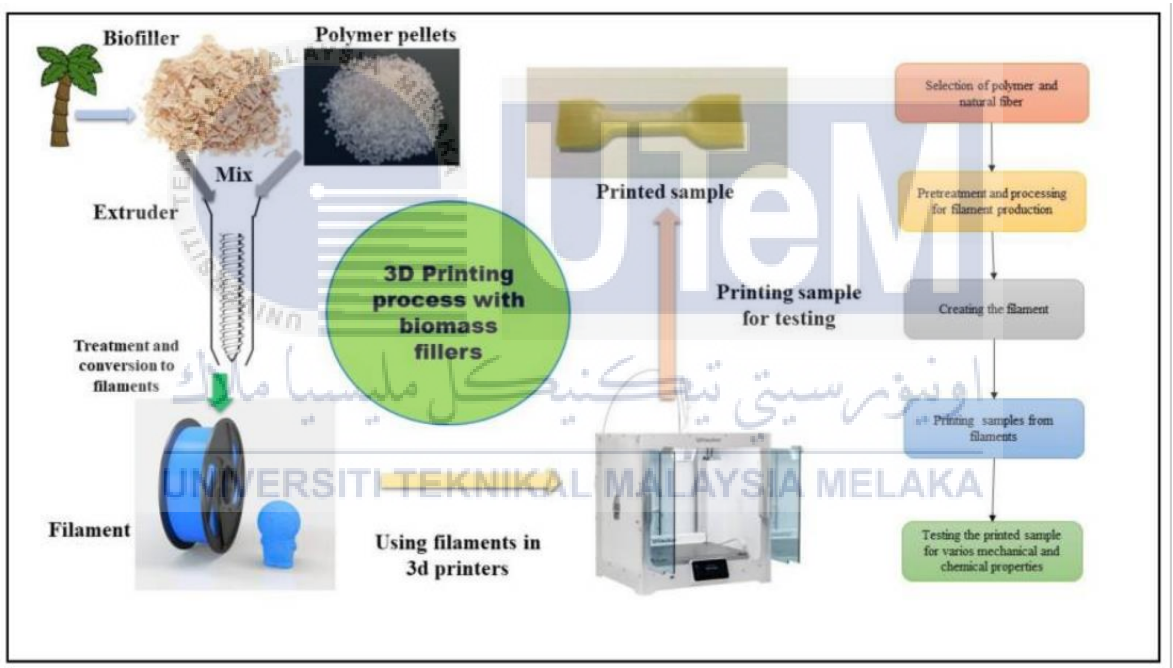

Figure 1. 1: The cycle of 3D printing using natural fibre

1.2 Problem Statement

In recent year, there has been rapid development in additive manufacturing or 3D printing technology to be used in designing and production sector. But there were a few problems that caused by 3D printing plastic waste which can affect the eco system because it non degradable property.

Secondly, the characteristic of the product that produced by common plastic filament which is PLA and ABS have some weakness. The filament from each material was low fatigue resistance. This can cause the product easily to crack when absorb high impact on it.

1.3 Research Objective

The aim of this research is to study the physical, mechanical and morphological properties of recycled polypropylene (PP) and wood dust as reinforcement natural fibre. Specifically, the objectives are as follows:

a) To characterize the physical and thermal properties of wood dust from furniture waste and recycled polyropylene.

b) To evaluate the effect of sodium hydroxide (NaOH) treatment on thermal properties of wood dust fibre.

c) To analyse the physical, morphological and mechanical properties of filaments made from recycled polypropylene (PP) filled with wood dust.

1.4 Scope of Research

The scope of this research are as follows:

- Testing and analyse physical, morphological, and thermal of wood dust fibre.
- Develop alternative material for 3D printing filament based on combination of Polypropylene (PP) and wood dust fibre.
- Material that used in this study was wood dust and recycled polypropylene (PP) with fibre loading 0%, 1%, 3% and 5%.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In today's global modern technology society, creating a high technology machine for a production purpose was an achievement for the people. One of the machines that have been innovated by a human is Additive manufacturing (AM) or 3D printing machine. This machine will print our desire product based on our design by using layer by layer of filaments. Fusion deposition modelling (FDM), stereolithography apparatus (SLA), electron beam melting (EBM), laminated object manufacturing (LOM), selective laser sintering (SLS), digital light projection (DLP), and other techniques are utilised in 3D printing. The aerospace, automotive, medical, architectural, education, and fashion industries have all benefited from this advanced technology. (Tao et al., 2017).

Although, using 100% plastic filaments may cause quite a high cost in production. An afford to try creating a new filament by using natural fiber such as wood dust filled with the recycled polypropylene may reduce the cost. The lower cost filaments were prepared combination of waste from wood dust and recycled polypropylene. By mixing these two different types of material may help to discover a new type of filament that can be used in a 3D printing machine and these new filaments might have a different quality and toughness compared with a plastic filament alone. (Joseph, 2018). In this chapter, everything that related with the use of wood dust and recycled plastic polypropylene will be highlighted to study its behavior and characteristic.

2.2 Natural fibre

The natural fibre is referred to the fibres that can be collected from nature either from animals or plants. Nowadays, the usage of these natural fibres has become among one of most usage in industries application especially in composite manufacture for multitype of product. Most natural fibre has a good ability in water absorption. So, this will help the researcher to make some experiments on the natural fibre through some chemical treatment to characterize these natural fibre properties. Depending on the source, natural fibres are classified as seed hair, bast fibres, or leaf fibres. Cotton (seed hairs), ramie, jute, and flax (bast fibres), and sisal and abaca are a few examples (leaf fibres). The most used fibres for polymer composites are jute, ramie, flax, and sisal. The natural fibre which in form of wood dust also one of the most favourite for the user or manufacture to use as a natural fibre composite for their production manufacturing (BYJU'S, 2021).

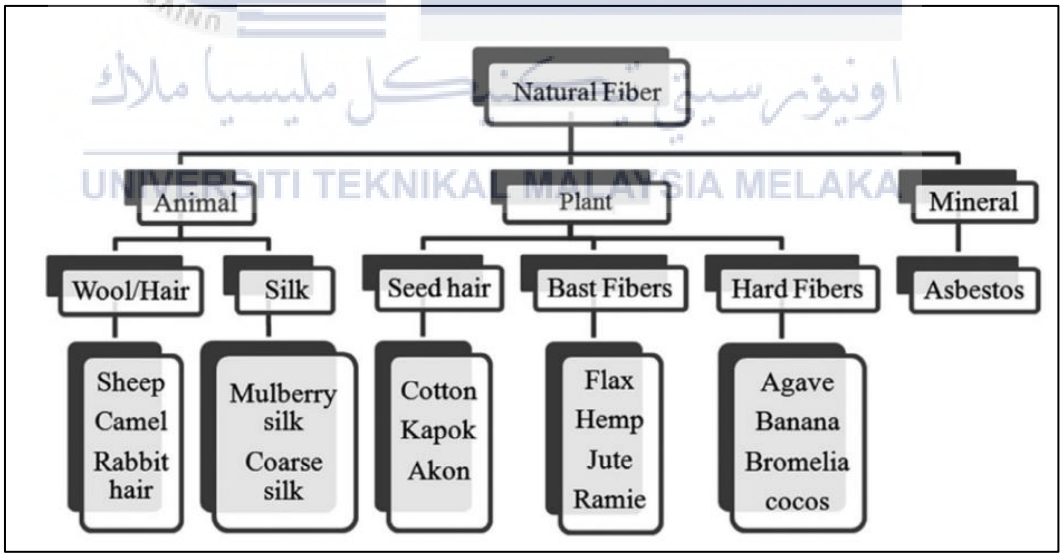

Figure 2. 1: Type of natural fibre(Omrani et al., 2016).

2.2.1 Characteristic of natural fibre

The important characteristic of natural fibres such as fibre diameter, fibre length and cell wall thickness can be seen in figure 2.2. The natural fibres have a broad variety of fibre diameters (5-76m), fibre bundle width (10-1000m), and lengths (1.2-300 mm), which result in significant differences in the properties of polymer composites prepared for these fibres. Furthermore, the characteristic differences of natural fibres present major difficulties in improving processing processes where the fibres are used as reinforcing materials. As a result, accurate feedstock content measurement and control are crucial for achieving desire output in NFRCS.(Balla et al., 2019)

Important characteristics of natural fibers [20,26,30].

Fiber	Shape	Dia./ width, µm	Bundle width, µm	Length, mm	Cell width/ dia., µm
Wood	Rectangular to round	5–50	–	1.2–3.6	10–30
Flax	Polygonal	5–76	40–620	4–140	–
Hemp	polygonal or ribbon-shape	5–40	25–500	8–55	4–60
Jute	Rectangular to Polygon	5–30	25–200	1–5	–
Kenaf	Round to polygonal	12–50	30–247	1.5–11	–
Abaca	Polygonal to round	6–46	10–1000	2–12	–
Sisal	Polygonal to round	4–47	9–460	0.5–8	–
Coir	Round to oval	10–30	50–460	150–300	10–30

Figure 2. 2: Important characteristics of natural fibres (Balla et al., 2019).

2.2.2 Structure of natural fibre

Identification of the natural fibre which is wood dust structure was an important factor that should be the focus on to produce a composite material. This characteristic is critical since it is directly related to performance and understanding the compatibility of