UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AN INVESTIGATION OF THE EFFECTIVENESS OF THE MAPP COMPATIBILISER ON THE 3D PRINTING FILAMENT PROPERTIES MADE FROM WOOD DUST/RECYCLED PP COMPOSITE (R-WOPPC)

AENDERSON CHAONG ANAK UJIH
B091910314

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

AN INVESTIGATION OF THE EFFECTIVENESS OF THE MAPP COMPATIBILISER ON THE 3D PRINTING FILAMENT PROPERTIES MADE FROM WOOD DUST/RECYCLED PP COMPOSITE (R-WOPPC)

Aenderson Chaong Anak Ujih

Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

2023

AN INVESTIGATION OF THE EFFECTIVENESS OF THE MAPP COMPATIBILISER ON THE 3D PRINTING FILAMENT PROPERTIES MADE FROM WOOD DUST/RECYCLED PP COMPOSITE (R-WOPPC)

AENDERSON CHAONG ANAK UJIH

**A thesis submitted
in fulfilment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Product Design) with Honours**

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled "An investigation of the effectiveness of the MAPP compatibiliser on the 3D printing filament properties made from wood dust/recycled PP composite (r-WoPPc)" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : Aenderson

Name : Aenderson Chaong Anak Ujih

Date : 27 January 2023

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 (Product Design) with Honours.

Signature : ....

Supervisor Name : Dr. Nuzaimah Bte Mustafa

Date : 27 January 2023

DEDICATION

I dedicated this study to God Almighty, my creator, my strong pillar, my source of inspiration, strength, wisdom, knowledge and understanding. I would like to thank my parents, relatives, and friends for believing in this study. I am also dedicated to my supervisor, who gave me the opportunity and trust to conduct this study even though I did not qualify. Also, to my mentor, who helped me to understand the basics of knowledge in conducting this study. Furthermore, my helpful friends s who assisted in many ways due to my own lack of many things and willingness to conduct this study together. Also, those people who have worked hard to help me complete this study.

ABSTRACT

The main purpose of this study is to investigate the effect of various loadings of maleic anhydride grafted polypropylene (MAPP) on mechanical, physical, and morphological characteristics of filament and 3D printed wood dust/recycled polypropylene composite (r-WoPPc) specimens. The r-WoPPc filaments were produced with MAPP loadings of 0%, 1%, 3%, and 5%, respectively. Wood dust, MAPP and recycled polypropylene were hot pressed, crushed and extruded using single extruder to produced r-WoPPc filament and printed into 3D printed specimens. R-WoPPc filament morphology was examined, and the 3D printed specimens were studied on tensile strength, flexural strength, water absorption properties and morphological. The results indicate that among all MAPP loadings, the addition of 5% MAPP into r-WoPPc was the best. Compared with before MAPP addition, it was enhanced by 39.468%. The MAPP reinforced the bond between recycled wood dust and recycled polypropylene matrix, therefore improved the strength of r-WoPPc.

ABSTRAK

Tujuan utama kajian ini adalah untuk menyiasat kesan pelbagai jumlah polipropilena cantuman anhidrida maleik (MaPP) pada ciri mekanikal, fizikal, dan morfologi filamen dan pada cetakan 3D komposit serbuk kayu/polipropilena kitar semula (r-WoPPc) spesimen. Filamen r-WoPPc dihasilkan dengan jumlah MAPP masing-masing 0%, 1%, 3%, dan 5%. Serbuk kayu, MAPP dan polipropilena kitar semula ditekan panas, dihancurkan dan diekstrusi menggunakan extruder tunggal untuk menghasilkan filamen r-WoPPc dan dicetak menjadi spesimen bercetak 3D. Morfologi filamen R-WoPPc diperiksa, dan spesimen bercetak 3D dikaji pada kekuatan tegangan, kekuatan lenturan, sifat penyerapan air dan morfologi. Hasilnya menunjukkan bahawa di antara semua jumlah MAPP, penambahan 5% MAPP ke dalam r-WoPPc adalah yang terbaik. Berbanding dengan sebelum penambahan MAPP, ia ditingkatkan sebanyak 39.468%. MAPP mengukuhkan ikatan antara serebuk kayu kitar semula dan matriks polipropilena kitar semula, oleh itu kekuatan r-WoPPc meningkatkan.

ACKNOWLEDGEMENTS

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

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Dr Nuzaimah Bte Mustafa, for all his support, advice and inspiration. Her constant patience for guiding and providing priceless insights will forever be remembered. My special thanks go to Mr. Nafis for all the help and support I received from them.

Last but not least, from the bottom of my heart a gratitude to my beloved parents, Ujih Ngalang and Semamu Belat for their endless support, love and prayers. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		**ii**
ABSTRAK		**iii**
ACKNOWLEDGEMENTS		**iv**
TABLE OF CONTENTS		**v**
LIST OF TABLES		**vii**
LIST OF FIGURES		**viii**
LIST OF SYMBOLS AND ABBREVIATIONS		**xi**
LIST OF APPENDICES		**xii**
CHAPTER 1	**INTRODUCTION**	**13**
1.1	Background	13
1.2	Problem Statement	13
1.3	Research Objective	14
1.4	Scope of Research	14
CHAPTER 2	**LITERATURE REVIEW**	**15**
2.1	Introduction	15
2.2	Plastic	15
	2.2.1 Polypropylene (PP)	17
	2.2.2 Polyethylene (PE)	17
2.3	Wood Dust	18
2.4	Treatment	19
2.5	Maleated	21
	2.5.1 Maleated polypropylene (MAPP)	21
	2.5.2 Maleated polyethylene (MAPE)	22
	2.5.3 Table of Composite	23
2.6	Sieve machine	24
2.7	Mixing	25
2.8	Extruder	26
2.9	3D filament	27
2.10	3D Printing	27
2.11	Summary	29

CHAPTER 3 METHODOLOGY 31
3.1 Introduction 31
3.2 Raw Material 32
3.2.1 Recycled Polypropylene 33
3.3 Preparation Material 34
3.3.1 Preparation for Wood Dust 34
3.4 Treatment 34
3.4.1 Preparation for Silane 34
3.4.2 Wood Dust 35
3.4.3 Treatment of Wood Dust 35
3.5 Preparation of filaments 36
3.5.1 Wood Dust/Recycled Polypropylene composite 36
3.6 Preparation of 3D printing 39
3.6.1 3D Printing process 39
3.7 Characterization 40
3.7.1 Wood Dust characterization 40
3.8 Specimen Test 41
3.8.1 Tensile Test 41
3.8.2 Flexural Test 42
3.8.3 Water Absorption Test 43
3.8.4 Morphological 44
3.9 Summery 45

CHAPTER 4 RESULT AND DISCUSSION 46
4.1 Introduction 46
4.2 Result and Analysis of Tensile testing 46
4.3 Result and Analysis of Flexural Test 48
4.4 Result and Analysis of Water Absorption properties 50
4.5 Morphological of r-WoPPc 52
4.6 Summary 54

CHAPTER 5 56
5.1 Conclusion 56
5.2 Limitation 57
5.3 Recommendations 58
5.4 Project Potential 58

REFERENCES 60

APPENDICES 66

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1: Treatment with different type of fibre		20
Table 2.2: The composite and Maleated as coupling agent		23
Table 3.1: Wood dust/polypropylene/MAPP formulations		36
Table 4.1 Result of Tensile Strength and Elongation		46
Table 4.2 Flexural strength		49
Table 4.3 Water absorption properties		50
Table 4.4 Morphological of r-WoPPc		52

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:Structure of Polypropylene (Banerjee et al., 2019)		17
Figure 2.2:The polyethylene and polypropylene(*Scienomics*, n.d.)		18
Figure 2.3:Alkali and MPS-silane (Hongsriphan, 2016)		19
Figure 2.4: Structure of maleric anhydride polypropylene(Harper & Wolcott, 2006).		22
Figure 2.5: Polyethylene-graft-maleic anhydride (PE)		22
Figure 2.6: Sieve machine		25
Figure 2.7: Sieve machine filter with different layer of particle size		25
Figure 2.8: Scheme of the geometry of a co-rotating twin-screw (Barrera et al., 2008).		26
Figure 2.9: Recycling scheme for 3D printing materials (Mikula et al., 2021)		27
Figure 2.10: Typical scheme of the 3D printing process (Banerjee et al., 2019).		28
Figure 2.11: Drawing of 3D printing specimen in unit mm (Banerjee et al., 2019).		29
Figure 2.12: 3D printed thermoplastic elastomers(Banerjee et al., 2019).		29
Figure 3.1 The Flow Chart		32
Figure 3.2: Wood dust		33
Figure 3.3: Recycled Polypropylene		33
Figure 3.4 Recycled polypropylene		34
Figure 3.5 Preparation on wood dust		34
Figure 3.6 10 ml silane, 49 ml of distilled water and 500 ml of silane solution		35
Figure 3.7 Silane Treatment on wood dust		36
Figure 3.8 Method to producing 3D filament		38

Figure 3.9 The mixed MAPP, wood dust and recycled polypropylene 39

Figure 3.10 3D Filament and 3D printer that use for printed requied specimens 40

Figure 3.11: Wood dust 40

Figure 3.12: The wood dust after Sieve process 41

Figure 3.13 Tensile strength test 42

Figure 3.14 Specimen after tensile strength 42

Figure 3.15 Flexural strength test 43

Figure 3.16 Specimens after flexural strength test 43

Figure 3.17 20 mm length of 3D filament after 30 days 44

Figure 3.18 Microscope 44

Figure 4.1 Tensile strength of r-WoPPc 47

Figure 4.2 Elongation of r-WoPPc 48

Figure 4.3 Flexural stress of r-WoPPc 49

Figure 4.4 Graph of water absorption test 51

Figure 4.5 Percentage of water absorption 51

Figure 0.1 Plagiarism 66

Figure 0.2 Gantt Chart PSM 2 66

Figure 0.3 Conducting Flexural strength test 67

Figure 0.4 Wood dust weight recorded 67

Figure 0.5 Specimens r-WoPPc on tensile test 68

Figure 0.6 Specimens condition during tensile test 68

Figure 0.7 Water absorption test 69

Figure 0.8 Small pieces of r-WoPPc vary MAPP loading 69

Figure 0.9 Pouring the methanol 70

Figure 0.10 Printed specimen r-WoPPc 70

Figure 0.11 Demonstration on product printed using r-WoPPc 3D filament 70

LIST OF SYMBOLS AND ABBREVIATIONS

PP	-	Polypropylene
PE	-	Polyethylene
MAPP	-	Maleated Polypropylene
MaPE	-	Maleated Polyethylene
r-WoPPc	-	Wood dust/recycled polypropylene composite
μm	-	Micrometers
%	-	Percent
WPC	-	Wood plastic composite
WF	-	Wood fibre

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A	Plagiarism	66

CHAPTER 1

INTRODUCTION

1.1 Background

There are many materials that able to recycle back to its original form and other form. The most of them are from waste material. Material waste are commonly produced from manufacturing site. Some of manufacturing site will recycle the waste and most of manufacturing will throw it. In Malaysia, the population is increasing at a rapid rate reaching 32.6 million in 2019. This has resulted in a tremendous amount of solid wastes being generated which was estimated at about 38,200 tons per day (1.12 kg/cap/day). In Malaysia, there are three types of recyclables such as paper, plastics and bottles, but very little of the waste is recycled. Malaysia also a larger plastic production industry within 1300 plastic manufacturing. Due to this matter, there are some step to manage plastic waste. One of is reuse the plastic by changing properties of it. The application of fibre as a reinforcement will have an impact on plastic manufacture. As a result, numerous studies have been conducted to promote the use of recycled plastic and to boost the production of plastic fibre. Among the study involves examine the effect of MAPP on r-WoPPc.

1.2 Problem Statement

Polypropylene is a well-known manufacturing material with excellent material characteristics. However, polypropylene alone is insufficient. New developments in wood fibre were created because of polypropylene's impact on the environment and disposal challenges. The wood plastic composites are an excellent material made. However, the qualities of the mixture of wood and plastic are insufficient to make it compatible with manufactured items. Besides, the current wood plastic composite is not tough as manufactured required. As a result, the study must determine the properties of a new wood plastic composite mixture.

1.3 Research Objective

The main aim of this research is to study the physical, mechanical, and morphological properties of wood dust/recycled polypropylene composite (r-WoPPc) and the effects of MAPP on them. Specifically, the objectives are as follows:

a) To evaluate the effect of the different MAPP loading toward mechanical properties of the 3D printing r-WoPPc specimen.

b) To investigate the physical properties of 3D printed r-WoPPc specimens with different MAPP loading.

c) To assess the effect of various MAPP loading on the physical properties of 3D printed r-WoPPc specimens.

1.4 Scope of Research

The scope of this research are as follows:

1. Analysis the physical, mechanical and morphological of wood dust fibre.

2. Develop of 3D printed from combination of wood dust/recycled polypropylene composite with different loading of MAPP.

3. Testing an analysis, physical, mechanical and morphological of wood dust/recycled polypropylene composite.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Plastic is a type of polymeric material that can be formed or moulded, usually by use of heat and pressure. Plasticity, which also is commonly combined with other particular features like low density, low electrical conductivity, transparency, and toughness, allows plastics to be manufactured into a variety of products (Yani et al., 2020).

Plastic is one of the most widely used materials due to its low cost, lightweight texture, durability, and ease of usage(Bauer et al., 2021a). According to some estimates, approximately 6.3 billion tons of plastic trash were produced in 2015, with 12 percent being burnt, 79 percent being buried, and only 9 percent being recycled (Geyer et al., 2017).

According to the Environmental Protection Agency, roughly 4.20 million tonnes of plastic garbage (bags, sacks, and wraps) were generated in the United States in 2018, while only about 0.42 million tonnes (or 10%) were recycled(Dillon et al., 2018). Malaysia has a population of 32 million people and generates 38 000 metric tonnes of rubbish every day, according to Malaysia's Housing and Local Government Minister (Ahmad et al., 2019) .

2.2 Plastic

Plastic is made up of massive molecules known as polymers. Polymers are macromolecules made up of a large number of smaller molecules, or repeating units, termed monomers, that are chemically bonded together (Marawar et al., 2017). Polymers are a type of natural or synthetic substance made up of big molecules called macromolecules that are multiples of minor chemical units known as monomers (Contents, 2022). Besides, polymer material is made up from living organisms.

Along with its properties, plastic is a substance that we may easily find in our daily lives. Plastic was used only once in some applications, such as plastic bottles. Furthermore, PET bottles are the most commonly used plastic bottles. (Abdel-Gawad et al., 2020). There are 7 type of plastic; there are polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP) and polystyrene (PS), marked with numbers 1 to 6 in each type. In addition, there is one more type of resin to signify plastic other than the preceding six, denoted by code seven and labelled "other" (Yani et al., 2020).

2.2.1 Polypropylene (PP)

Probably one of the best commodity polymers produced in the automobile sector, polypropylene (PP), is an ideal light-weight candidate material for fulfilling the ever-increasing needs of electric vehicles (Tsai et al., 2021). Example of polypropylene are bottle caps, rope, tape and cloth. Polypropylene is related to polyethylene, although it is considerably more resistant to impact fractures (Jeon et al., 2021).

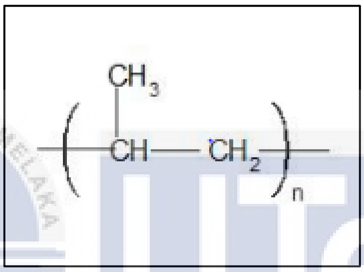

Figure 2.1:Structure of Polypropylene (Banerjee et al., 2019)

Because of its unique features, including as high melting temperature, low density, excellent chemical resistance, and heat tolerance, polypropylene has a wide range of applications. Polypropylene, on the other hand, has a low impact strength, which limits its use in a variety of applications (Mohamad et al., 2013a). Furthermore, when compared to low or high-density polyethylene, it performs better under a variety of operational temperatures, has higher tensile strength, but lower impact strength (Razak et al., 2018).

2.2.2 Polyethylene (PE)

Due to its enormous annual production capacity and good cost performance, polyethylene (PE) is one of the most important commercial polymer products in the world's polymer market, and it is widely used for plastic items (Tsai et al., 2021). Polyethylene usually used to make plastic bags, bottles, plastic films, containers and geomembranes. Polyethylene formula written as $(C_2H_4)_n$. Different synthetic pathways can be used to make polyethylene, and polyethylene in the melt is a major step in both industrial solution polymerization processes (Sun et al., 2022). Figure 2.2 show a most common used synthetic polymer material structure, polyethylene and polypropylene.

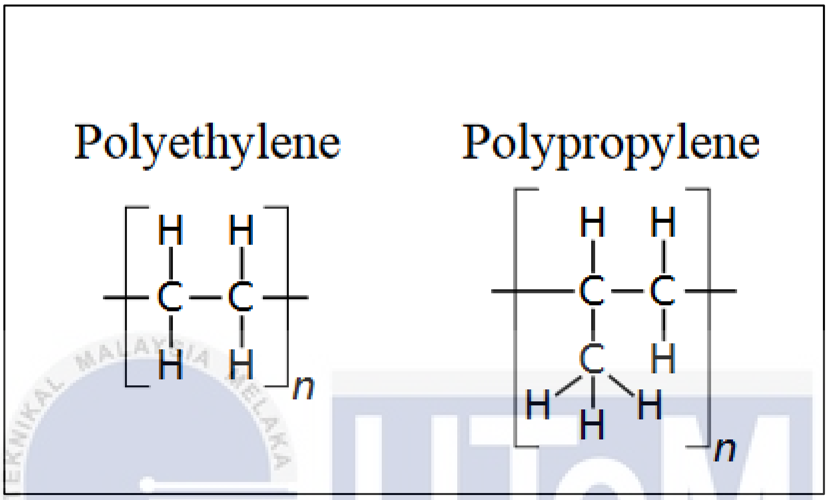

Figure 2.2:The polyethylene and polypropylene(*Scienomics*, n.d.)

2.3 Wood Dust

As indicated by high level of wood chips from harvesting activities, the majority of forest trash, particularly wood dust, wasn't used and utilized properly(Wang et al., 2014). This prove that wood waste needs to recycle. Wood dusts are also a recycling and reusing resource that has been used to produce polymer-based composites. Composites are increasingly being used in a variety of applications, including manufacturing, vehicles, architecture, entertainment, and other widespread industries (Chauhan et al., 2021a).

Chipped wood as production waste can be categorized by significant variability based on the variety of wood being machined or the category of wood material, as well as size and shape variations of particles produced of different machining techniques and parameters. Wood dust is an overall and imprecise term because chipped wood as manufacturing waste can be categorized by great variation depending on the species of wood being machined or the type of wood material, as well as size and shape different versions of particles produced of various methods and specifications of machining.

2.4 Treatment

Before proceeding through main process of making composites, the wood dust from in this study must be treated. In this study, there are numerous treatments for wood dust can be used. Silane treatment, Alkali, tannic acid, and Fe2+solution were often used (Hongsriphan, 2016)(Elsheikh et al., 2022a). To improve the interfacial bonding between of composite materials, study were using a solution of silane and maleated coupling agents to treat PP/WF/rubber WPC. (Elsheikh et al., 2022b).

Figure 2.3:Alkali and MPS-silane (Hongsriphan, 2016)