UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THE EFFECT OF MAPE ON THE 3D PRINTING FILAMENT PROPERTIES MADE FROM WOOD DUST/RECYCLE PP COMPOSITE (R-WOPPC)

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (Product Design) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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DECLARATION

I declare that this Choose an item. entitled "Study On The Effect Of MAPE On The 3D Printing Filament Properties Made From Wood Dust and Recycle PP (r-WoPPr)" 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 :

Name : MOHD HAFIZI BIN HALIM

Date : 11/1/2023

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

To my beloved mother and father thank you for always supporting me throughout this Final year project.

To my supervisor, Dr NUZAIMAH BTE MUSTAFA who always help me finish this project and always make sure I am on the right track and following all the formats for this report.

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ABSTRACT

The goal of this research was to investigate the effect of MAPE as a compatibilizer on the morphological, mechanical, and physical properties of 3D printing filaments made from wood dust and recycled polypropylene (R-WoPPc). Four R-WoPPc filaments with MAPE loadings of 0%, 1%, 3%, and 5% by weight were produced and printed into 3D specimens. The morphology of R-WoPPc filament was studied, as well as the properties of printed specimens such as tensile properties, flexural properties, microstructure, and physical properties. The results revealed that 1% MAPE in R-WoPPc yielded the highest performance for the material's microstructure, tensile strength, water absorption, and flexural strength. Tensile strength improved by 74.07% compared to without MAPE addition and was the highest among all MAPE loadings. The MAPE strengthened the adhesion between recycled wood dust and recycled polypropylene matrix, resulting in improved R-WoPPc performance. Pure addition of filler and matrix causing pure properties or strength.

ABSTRAK

Matlamat penyelidikan ini adalah untuk menyiasat kesan MAPE sebagai penyerasi terhadap sifat morfologi, mekanikal dan fizikal filamen cetakan 3D yang diperbuat daripada habuk kayu dan polipropilena kitar semula (R-WoPPc). Empat filamen R-WoPPc dengan muatan MAPE sebanyak 0%, 1%, 3% dan 5% mengikut berat telah dihasilkan dan dicetak ke dalam spesimen 3D. Morfologi filamen R-WoPPc telah dikaji, serta sifat spesimen bercetak seperti sifat tegangan, sifat lentur, struktur mikro, dan sifat fizikal. Keputusan menunjukkan bahawa 1% MAPE dalam R-WoPPc menghasilkan prestasi tertinggi untuk struktur mikro bahan, kekuatan tegangan, penyerapan air dan kekuatan lenturan. Kekuatan tegangan bertambah baik sebanyak 74.07% berbanding tanpa penambahan MAPE dan merupakan yang tertinggi di antara semua beban MAPE. MAPE mengukuhkan lekatan antara habuk kayu kitar semula dan matriks polipropilena kitar semula, menghasilkan prestasi R-WoPPc yang lebih baik. Penambahan tulen pengisi dan matriks menyebabkan sifat atau kekuatan tulen.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
cm	-	Centimeter
mm	-	Milimeter
Mpa	-	Mega Pascal
%	-	Percent
kN	-	Kilo Newton
Kg	-	Kilogram
g	-	Gram
°	-	Degree
µm	-	Micron meter
rpm	-	Revolution Per minutes
rPP	-	Recycle Polypropylene
rWD	-	Recycle Wood Dust
PP	-	Polypropylene
WF	-	Wood Fiber
WD	-	Wood Dust
MAPE	-	Maleated Anhydride Grafted Polyethylene
MAPP	-	Maleated Anhydride Grafted Polypropylene

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CHAPTER 1

INTRODUCTION

1.1 Background

In our modern era, additive manufacturing, also known as 3D printing, has advanced significantly in the recent decade. When compared to subtractive manufacturing, it has various advantages, including the capacity to make complicated forms and products without the use of specific equipment or molds. As a result, it will be great for prototyping and customizing items. FDM is a popular method of 3D printing. FDM printers fuse filament and print products layer by layer, as the name implies. There are filaments of many types, including bio-composite filaments. Due to their inexpensive price, extensive availability, high strength-to-weight ratio, high aspect ratio, and high strength and elasticity modulus, bio composite filaments are an excellent alternative to synthetic filaments (Deb & Jafferson, 2021).

The invention and testing of eco-friendly and recyclable materials such as wood, cellulose, sugars, and lignin has created a lot of interest in biodegradable 3D printing. Fiber, particle, and nanocomposite reinforced materials have also sparked interest, and several materials containing wood particles have recently hit the market. For 3D printing with wood, fused deposition modelling (FDM), injection powder printing, and liquid/paste deposition modelling have all been employed (Rafiee et al., 2021).

Natural fibers are increasingly being used as reinforcing charges in polymeric materials due to their technological advantages, environmental benefits, and economic benefits. Natural fibers are rapidly being viewed as a viable alternative to synthetic fibers due to their diversity, availability, and renewability. But however, it's hydrophobic its compatibility with the polyolefins and/or elastomers, necessitating surface modification via treatment with chemicals or the application of coupling agents, which aid in improving interfacial addition with the polymer hydrophobic matrix (Palacio et al., 2020). Because the bonding strength between wood fiber (polar-hydrophilic material) and polyolefin (non-polar-hydrophobic polymers) is inadequate, a compatibilizer (coupling agent) must be added to improve the bonding strength between the wood fiber and the polymer matrix. There has been a lot of research towards optimizing the interface between wood fiber and polymer. Maleic anhydride-grafted polymer is one of the most useful coupling agents for WPC (Yuan et al., 2008).

The goal of this study, which used MAPE as a coupling agent, was to see if esterification was a significant factor for interfacial adhesion mechanisms of ultra-highly packed wood fiber polyethylene composites (UH-WPCs) based on existing findings. Furthermore, UH-WPCs were effectively extruded utilizing HDPE or MAPE as the polymer matrix at various wood fiber percentages. The mechanical characteristics, creep behavior, water absorption, and surface contact angle of UH-WPCs with and without MAPE were compared. The interfacial adhesion mechanism of UH-WPCs was studied using polymer matrix blends and wood fiber isolated from the UH-WPCs (Hao et al., 2021). Several investigations have been conducted to enhance the composite's strength. As a coupling agent in WPCs, maleated polyolefins (MAPE and MAPP) are frequently used. Adding 1% to 5% MAPE or MAPP to the mix can improve the mechanical properties (r-WoPPc).

As a coupling agent in recycled polypropylene (PP) and wood dust fiber (WDF), the maleated polyethylene (MAPE) was studied. The incorporation of MAPE was carried out during the mixing stage. The effect of the MAPE content on composite of (r-WoPPc) compatibility was analyzed.

1.2 Problem Statement

In today's advance age, it has come into existence about rapid development in additive manufacturing or 3D printing technology to be used in designing and for production sectors. However, there are still some problems that which may stem from 3D printing plastic waste where this is possible can affect the eco system such as waste of the polypropylene polymer. This is because it is non degradable property. Other than that, many wood dust residues are left unattended without knowing that the wood dust fiber can be recycled and made into filaments.

Secondly, the characteristic of the product that be produced by some of the common plastic filament which is PLA and ABS have some weakness. The filament from each material was low of the fatigue resistance. Overall, this can cause the product are easily to crack in certain part due to absorb high impact on it. Same goes to the composite filament which is the enhancing the bonding strength between the wood fiber and polymer are not strong enough without the agent coupling or compatibilizer.

1.3 Research Objective

The aim of this research is to study the physical, mechanical, and morphological properties of recycle polypropylene (PP) and recycle wood dust as reinforcement natural fiber by adding maleated-anhydride-grafted polyethylene (MAPE).

Specifically, the objective as follows:

a) To characterize morphological properties of r R-WoPPc filament on different MAPE loading.

b) To evaluate the effect of the different MAPE loading toward mechanical properties of the 3D printing R-WoPPc specimen.

c) To investigate the physical properties of 3D printing R-WoPPc filament on different MAPE loading.

1.4 Scope of Research

The scope of this research is as follow:

a) Testing and analyze physical, morphological, and mechanical of recycle of wood dust and polypropylene composite by using MAPE.

b) Develop alternative material for 3D printing filament based on combination of Polypropylene (PP), Wood dust Fiber, and maleated-anhydride-grafted polyethylene (MAPE).

c) Material that used in this study was wood dust, recycle polypropylene and MAPE with loading 1%, 3% and 5%.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The section begins by providing essential of the 3D printing process theory and also common plastics in use today that is using in the production of the 3D printing filaments. Next, I'll go over the natural fiber and composite materials used in 3D printing that are already on the market. Second, some relevant information about the materials under consideration for this work, which is a coupling agent maleic anhydride grafted polyethylene (MAPE) for natural fibers with a focus on recycled PP or PP (Polypropylene), is reviewed. In addition, in-depth look at the manufacturing procedure used in the filament's production was provided, goes as well for some theoretical information on the other method employed in the experiment.

2.2 3D Printing

2.2.1 3D Printing History

(Shahrubudin et al., 2020) found that additive manufacturing, often known as 3D printing, is a method of fabricating tangible objects out of computer models by gradually adding materials to the models. 3D printing is increasingly commonplace all around the world. In the fields of agricultural, healthcare, automotive, locomotive, and aviation, 3D printing is rapidly being utilized for mass customization and manufacture of open-source designs of all kinds. Layer-by-layer deposition of material is utilized in 3D printing to construct an object directly from a computer-aided design (CAD) model. Charles Hull pioneered 3D printing, commonly known as "Stereo-lithography," in the 1980s. This technology interprets data in CAD files (Computer Aided Design) and allows them to be electronically transformed to 3D printers using the ".stl" format (Šramka & Ružický, 2016). By layering materials, 3D printing may turn a geometric representation into an actual thing. Since it was first commercialized in 1980, 3D printing technology has advanced at a breakneck pace. Since then, complicated walls, endodontic guides, athletic shoes, aviation engine parts, and tumor repair have all been created using this method (Shahrubudin et al., 2019).

Additive Manufacturing is another word for 3D printing. In the early 1980s, additive manufacturing was mostly used to create prototypes, but due to its precision, repeatability, and low production costs, its popularity has grown in recent years. FDM is a 3D printing method created by Stratasys in 1989. According to them, in a 3D printer, the extruder nozzle melts the filament in the heat sink before extruding it via the feeder, which feeds the filament through a nozzle (Shaik et al., 2021). Since Charles Hull's thoughts about a computer system based on stereolithography that uses the STL file format to understand data in a CAD file in 1984, many types of 3D printers have been deployed. The STL file contains information like as the color, texture, and thickness of the object to be printed, among other things. Numerous printing machines have been designed to print a wide range of things in different sectors (such as food and automotive) on a variety of scales (Shahrubudin et al., 2020).

To summarize, according to (Lee et al., 2017) was demonstrated that in the recent past, 3D printing application has emerged as a technology that is both diverse and powerful in the advanced manufacturing industry. Many countries, notably in the manufacturing sector, have adopted this technology.

2.2.2 3D Printing Process

(Šramka & Ružický, 2016) noted that the term 3D printing initially referred to a technology developed by scientists at the Massachusetts Institute of Technology (MIT) in 1993 and licensed to several companies. Today, the phrase is used to describe several processes that are all related. Designing using a computer (CAD) is at the heart of them all. CAD software