DEVELOPMENT OF CHEMICALLY TREATED SUGAR PALM FIBRE REINFORCED PLA COMPOSITE THROUGH FUSED DEPOSITION MODELLING 3D PRINTING.

ASRUL HAYAT BIN ABDUL RAZAK
B091810298

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS) WITH HONOURS

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DECLARATION

I declare that this Choose an item. entitled " Development of chemically treated sugar palm fibre reinforced PLA composite through Fused Deposition Modelling 3D Printing." 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 : Asrul Hayat Bin Abdul Razak

Date : 27/1/2022

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 Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

Signature :

DR. MASTURA BINTI MOHAMMAD TAHA
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Pembuatan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Supervisor Name : DR MASTURA BINTI MOHAMAD TAHA.

Date : 27/1/2022

DEDICATION

In the name of Allah, the Most Gracious, the Most Merciful and all praises to the Prophet, Muhammad S.A.W. Alhamdulillah, praise to Allah for His mercy, I have successfully completed this project in a timely manner.

I would like to take this opportunity to extend my utmost gratitude and sincere appreciations, to my mother, **Nor Fazila Binti Zabri** and my father **Abdul Razak Bin Mat Noh** for their support and sacrifice to confront with all problems and difficulties along this journey, mentally and physically.

May Allah rewards all of you with goodness and prosperity, here and hereafter

ABSTRACT

Nowadays, 3d printers is an advanced technologies that use to tangible objects that occupy space. Like a normal paper printer, 3d printer also need an ink or filler to perform printing process but what make it difference is, ink for 3d printer is in solid state and it is called filament. Polylactic acid (PLA) and Acrylonitrile Butafiene Styrene (ABS) is a common material use to create filament. Printing using filament that contain 100% PLA can only withstand small load or force which mostly use to create product that can be use as a prototype or merchandise. Other than that, PLA can be recycle but due to its low melting point, recycling PLA is not main consideration. In this research, the main focus is to create biocomposite material to use as a material to create a filament that will has stronger and higher thermal deflection properties. The idea is sugar palm fibre as natural fibre will reinforced by PLA as matrix. Creating this biocomposite material will need several process from degradation of SPF, fibre treatment, mixing, extrusion process until the analysis phase which is thermogravimetric (TGA) , Differential scanning calorymetri, and rhological studies. Creating hypothesis of this research required 4 specimen to undergoes these 3 analysis which is untreated SPF,and treated SPF that divided in three treatment which is NAoH solution, silane solution, and NAoH + Silane treatment. It is believed that biocomposite material will have higher melting point, stronger bond, and higher thermal stability which make it will be usable as a daily product and better at recycling process.

ABSTRAK

Hari ini, pencetak 3D ialah teknologi canggih untuk objek ketara yang menggunakan ruang. Seperti pencetak kertas biasa, pencetak 3d juga memerlukan dakwat atau pengisi untuk melakukan proses pencetakan, tetapi perbezaannya ialah dakwat pencetak 3d adalah pepejal, yang dipanggil filamen. Asid polilaktik (PLA) dan akrilonitril butadiena stirena (ABS) adalah bahan biasa untuk membuat filamen. Pencetakan dengan filamen yang mengandungi 100% PLA hanya boleh menahan beban atau daya yang kecil dan digunakan terutamanya untuk mencipta produk yang boleh digunakan sebagai prototaip atau produk komersial. Di samping itu, PLA boleh dikitar semula, tetapi mengitar semula PLA bukanlah pertimbangan utama kerana takat leburnya yang rendah. Dalam penyelidikan ini, tumpuan utama adalah untuk mencipta biokomposit untuk digunakan sebagai bahan untuk membuat filamen dengan sifat ubah bentuk haba yang lebih kuat dan lebih tinggi. Ideanya ialah gentian kelapa sawit sebagai gentian semula jadi akan diperkukuh oleh PLA sebagai matriks. Pembuatan biokomposit ini memerlukan beberapa proses bermula daripada degradasi SPF, pengendalian gentian, pencampuran, proses penyemperitan hingga ke peringkat analisis termogravimetrik (TGA), kalorimetri pengimbasan pembezaan dan kajian reologi. Membina hipotesis untuk kajian ini memerlukan 4 sampel untuk 3 analisis ini, SPF tidak dirawat dan SPF dirawat, dibahagikan kepada tiga rawatan, larutan NAoH, larutan silane, dan rawatan NAoH + silane. Adalah dipercayai bahawa biokomposit akan mempunyai takat lebur yang lebih tinggi, ikatan yang lebih kuat dan kestabilan haba yang lebih tinggi, membolehkan ia digunakan sebagai barangan harian dan dikitar semula dengan lebih baik.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

In the first chapter, project introduction was explained which contain the project background, problem statement, objective and work scope

1.1 Background

In this decade, the expanding rate of technology is very high. This scenario has conducted inventory of many products that use to create others product for example is the existence of 3d printer. The first 3D printers were introduced to the market in the mid-1990s. In this day, A variety of technologies are used in 3D printers. Fused deposition modelling (FDM), also known as fused filament fabrication, (FFF) is the most well-known technologies used . It involves melting and depositing layers of acrylamide butane styrene (ABS), polylactic acid (PLA), or another thermoplastic filament through a heated extrusion nozzle.

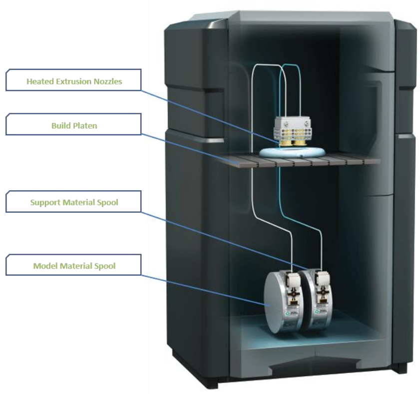

Figure 1 Fused Desposition Modelling 3D-printers (*Fused Deposition Modeling FDM 3D Printing Technology | How It Works*, n.d.)

Fig.1.1 Fused Desposition Modelling 3D-printers (*Fused Deposition Modeling FDM 3D Printing Technology | How It Works*, n.d.)

Commonly, the usage of 3d printer is only limited from presenting level such as demonstration, prototype and model , to moderate or soft duty product. It is due to the properties of the filament is not strong enough to be use in bigger or stronger field..

Creating better environment for 3d printer by using bio-composite filament for example by reinforcing PLA with natural fibre, such as sugar palm. Bio-composites have less environmental footprints, hence, they are safer for humans and other living habitats and they are recyclable and reusable. The mechanical performance of fiber-reinforced composites can be affected by many factors including the volume or weight fraction of the reinforcement, the orientation of the fibers, the fiber aspect ratio, fiber-matrix adhesion, fiber alignment, distribution, use of additives, and chemical treatment of fibers. It is important to add that the moisture absorption of the composites also affects the mechanical behavior of the composites which leads to the poor interfacial bonding between fiber and hydrophobic matrix polymer (Thyavihalli Girijappa et al., 2019).

The degraded fibre will undergoes chemical treatment that has the main purpose which is to enhance the properties of the fiber itself by modifying their microstructure along with improvement in wettability, surface morphology, chemical groups and tensile strength of the fibers (Siakeng et al., 2019)

Mixing polylactic acid(PLA) with natural fibre (sugar palm fibre) is to create sturdy, higher melting point and etc filament for fusion filament fabrication or fused deposition modelling (FDM) . new biocomposite material will went through Thermogravimetric analysis (TGA) and Differential scanning calorimetry (DSC) to characterize materials used in various environmental, food, pharmaceutical, and petrochemical applications and measure the amount of energy absorbed or released by a sample when it is heated or cooled, providing quantitative and qualitative data on endothermic and exothermic processes respectively. Thermogravimetric analysis (TGA) is performed on an instrument called a thermogravimetric analyzer. As the temperature of the sample changes over time, the thermogravimetric analyzer continuously measures the mass. Mass, temperature, and time are considered as baseline measurements in thermogravimetric analysis, and many other measurements can be derived from these three baseline measurements (Bottom, 2008).

Differential Scanning Calorimetry (DSC) is a thermal analysis technique in which heat entering or leaving the sample is measured as a function of temperature or time while the sample is exposed to a controlled temperature program. It is a very powerful technique that can be used to evaluate material properties such as glass transition temperature, melting, crystallization, specific heat capacity, curing process, purity, oxidation behavior, and thermal stability. DSC analysis can provide test data for various materials including polymers, plastics, composites, organic materials, rubber, petroleum, chemicals, explosives, biological samples (*Differential Scanning Calorimetry (DSC) Analysis*, n.d.).

1.2 Problem Statement

3D printing, also known as additive manufacturing, is becoming popular with manufacturers. The demand is growing due to some of the revolutionary benefits that it can provide. Like almost all technologies it has its own drawbacks that need considering.

3D printing process can create items from a variety of plastics, the available raw materials are not exhaustive such as PLA . PLA material can be recycle but due to its low melting point, recycling PLA is not main consideration and not giving to much benefit.

Due to a tremendous rise in demand and a concurrent supply deficit, the price of PLA filament has been continuously rising. Because this is one of the most often used 3D printing materials, the price hikes have many customers in a frenzy.

There are various ways for 3D printing, but the most common is a technique known as Fused Deposition Modeling (FDM). FDM printers use a thermoplastic filament, which is heated to its melting point and then extruded, layer by layer, to create a three dimensional object. Under this circumstances, due to properties that is low in strength and low heat deflection temperature FDM is only limited in modelling or prototype rather than functional parts.

Creating biocomposite filament that have good in strength, the data of its thermal properties need to be obtain so that the temperature of the nozzle of the 3d printer can be sync with the filament thermal properties. The deformaton of biocomposite filament when flow at different speed during melt state need to be observe to see whether the filament suit the nozzle of the 3d printer.

1.3 Research Objective

The objective of this project are :

- • To develop sugar palm fibre reinforce PLA composite through extrusion mixed with different treatment fibre and untreated fibre.
- To Characterize thermal and reological properties of the composite

1.4 Scope of Research

I. Sugar palm fibre as natural fibre.

II. Matrix used is polyactic acid (PLA).

III. Sugar palm fibre (SPF), will go through degradation process until the SPF is in powder form (125 μm).

IV. Different treatment SPF which is alkali solution,silane solution treatment, alkali-silane solution and untreated SPF will mix with PLA .

V. Filament deposite through twin-screw extruder machine.

VI. Thermal properties using TGA and DSC analysis and rheological study finding.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Chapter 2 will be some discussion about the research background related to the project. This chapter also discusses the journals as references and examples from other sources linked to the project.

2.1 Natural Fibre

Natural fibre, any hair-like raw material obtained directly from an animal, vegetable, or mineral source and converted into nonwoven textiles such as felt or paper, or woven cloth after spinning into yarns.

Figure 2 Sugar Palm Fibre

A natural fibre is further described as an aggregation of cells with a diameter that is minimal in contrast to the length. Aside from economic concerns, the commercial utility of a fibre is decided by qualities such as length, strength, pliability, elasticity, abrasion resistance, absorbency, and other surface qualities. The majority of textile fibres are thin, flexible, and somewhat robust.. They are elastic in that they stretch when put under tension and then partially or completely return to their original length when the tension is remove (Kamalnath et al., 2018).

2.2.1 Classification of Narutal fibre

Natural fibres are classed based on whether they are derived from plants, animals, or minerals . Natural plant fibres, on the other hand, are the most often utilised reinforcing material in biocomposites. Plant fibres are classified according to the kind of plant or portions of the plant from which the fibres were collected. Figure below depicts the major plant fibre classifications, which include bast, leaf, seed, and fruit, stalk, and grass fibers. All these mentioned plant fibers are term as non-wood fibers. Of late, many researches focus on the usage of non-wood fibers (Sanyang et al., 2016).

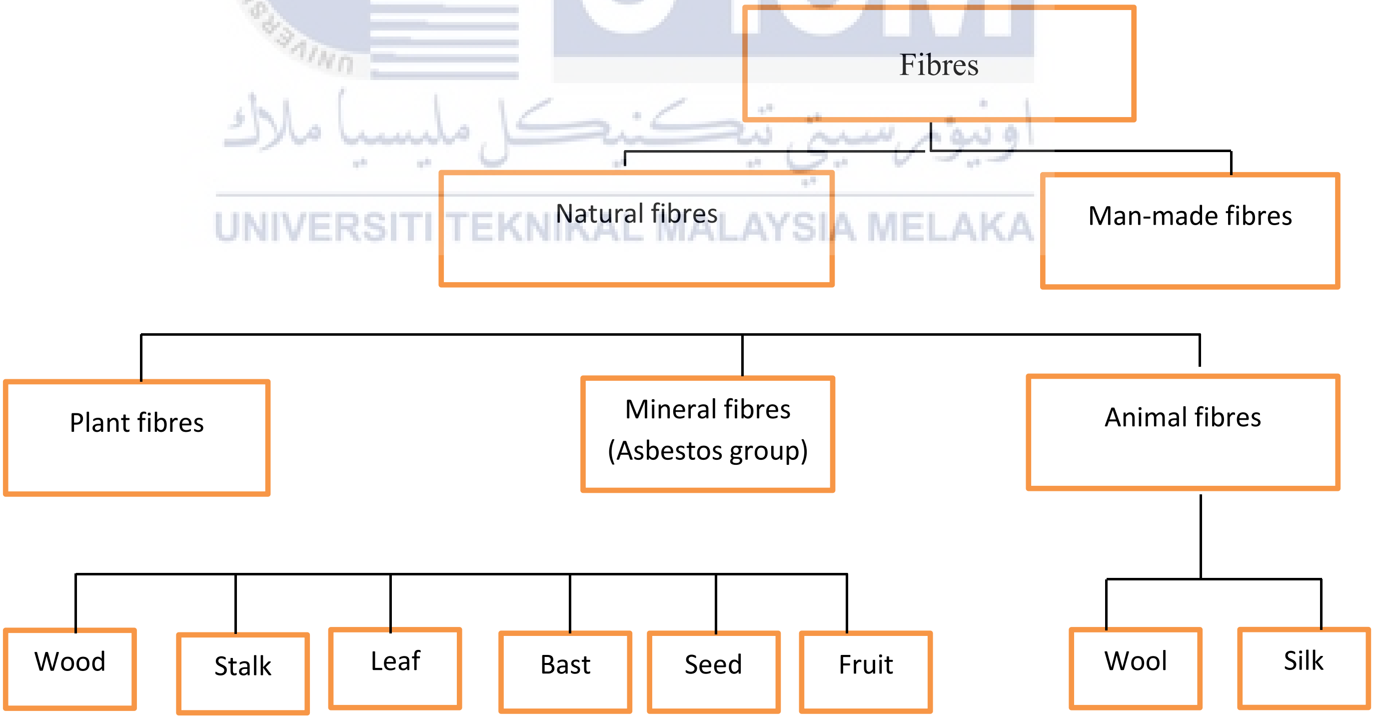

Figure 3 Chart of classification of Natural fibre (Kamalnath et al., 2018)

2.2.2 Sugar palm fibre (Arenga Pinnata)

Sugar palm is a massive and tall palm with a single unbranched stem that may reach 20 metres in height and 65 centimetres in diameter. The trunk is covered in long black fibres and the roots of broken leaves.The trunk can also be used to store starch.The starch is generally converted into sugars at the commencement of flowering for the production of seeds or tapped palm juice.

Figure 4 Sugar Palm Tree Fibre

The palmae family includes the sugar palm tree (Arenga pinnata). This plant is commonly found in the hot, humid parts of the Asian tropics, and it has a wide range of uses, making it a useful palm species. Sugar palm fibre, as a relatively new natural fibre in comparison to other natural fibres, can be classified in a variety of ways.The reason for this is that the fibre of the sugar palm tree might come from a cluster, a frond, or the trunk (Essaadani et al., 1991).

Malaysia, as a tropical country, has an abundance of natural fibre resources. Sugar palm fibre (locally known as ijuk fibre) is one of the plentiful natural fibres found in Malaysia,