THE EFFECT OF DISPERSION ON THE MECHANICAL PROPERTIES OF PLA-BASED POLYMER COMPOSITES

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This thesis is submitted in partial fulfillment of the requirements for the award of Bachelor of Mechanical Engineering (Structure & Materials)

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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged"

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Special dedications to my beloved family especially to my parents, Yaacob Bin Senin and Fazilah Binti Mohamed Noor and also do not forgotten to my lovely husband, Mohd Khairil Iszan Bin Hj. Abu Bakar

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ABSTRACT

This project investigates the effect on mechanical properties when pineapple leaf fibres (PALF) are reinforced with bio-based polymer, polylactic acid (PLA). At the same time, production of this biocomposite is aiming to replace the non-biodegradable plastic. Alkaline treatment was employed to modify the strength of PALF and to improve fiber to matrix adhesion. PALF reinforced PLA biocomposites are made by using compression moulding process. PLA thin films were stacked together with unidirectional aligned PALF fibre prior to compression moulding via hot press machine to form a biocomposite plate. Mechanical properties of PALF reinforced PLA biocomposite shows a superior improvement with alkaline treatment. Three types of test were considered for this project which is tensile test (ASTM D3039), flexural test (ASTM D790) and impact test (ASTM D6110). Scanning Electron Microscope (SEM) was used to scrutinize the morphology of the PALF reinforced PLA biocomposite as well as to investigate dispersion on the biocomposite. It was demonstrated that a superior enhancement on mechanical properties of PALF reinforced PLA biocomposite can be achieved via the efficient of stress transfer at well uniform fibre-matrix dispersion.

ABSTRAK

Projek ini mengkaji kesan ke atas sifat mekanikal apabila gentian daun nanas (PALF) diperkukuhkan dengan bio-polimer, polilactic asid (PLA). Pada masa yang sama, penghasilan biokomposit ini adalah bertujuan untuk menggantikan plastik yang tidak mesra alam. Rawatan alkali telah digunakan untuk mengubah suai kekuatan PALF dan untuk meningkatkan lekatan gentian-matrik. PALF bertetulang biokomposit PLA dibuat dengan menggunakan acuan mampatan proses. Filem PLA nipis telah disusun bersama-sama dengan PALF yang telah disusun dengan satu arah sejajar sebelum ia dimampatkan menggunakan mesin acuan mampatan untuk membentuk kepingan biokomposit. Sifat mekanikal PALF bertetulang PLA biokomposit dengan rawatan alkali menunjukkan peningkatan yang tinggi. Tiga jenis ujian mekanik telah dipertimbangkan untuk projek ini iaitu ujian regangan (ASTM D3039), ujian lenturan (ASTM D790) and ujian hentaman (ASTM D6110). Mikroskop Imbasan Elektron (SEM) telah digunakan untuk meneliti morfologi PALF bertetulang PLA biokomposit serta untuk menyiasat penyebaran gentian daun nenas di dalam biokomposit. Ia telah menunjukkan bahawa peningkatan yang unggul dalam sifat mekanik bagi PALF bertetulang PLA biokomposit boleh dicapai melalui perpindahan tegasan yang cekap dan penyebaran gentian-matrik yang seragam.

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LIST OF SYMBOLS

$\boldsymbol{v}$	=	Volume fraction
$\boldsymbol{w}$	=	Weight fraction
$\boldsymbol{V}$	=	Volume
$\boldsymbol{W}$	=	Weight
°C	=	Degree Celsius
σ	=	Stress
ε	=	Strain
$\boldsymbol{E}$	=	Modulus of Elasticity
%	=	Percentage
wt%	=	Weight Percent

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Polymeric material may be regarded as a renewable source with good potential on the biodegradability or compost ability in order to reduce the overall environmental impact since over the past decades. The result from this has brought the academic and industrial people of polymer composite towards the biodegradable polymers from renewable resources for many kind of application [1]. In this context, biodegradable polymers like polylactide acid (PLA) as one of the natural fiber-based polymer have been subject of many researches during the past decade [2]. In order to produce an alternative material which can replace the conventional petroleum-based plastics, the technological innovation has been developing the scientific knowledge of producing new materials [3]. The succesful development of a new material will bring a lot of benefits to humankind and the environment. As for example, by making use of biodegradable material can reduce the impact of overall environmental. The constraints that always arise when the desire to fulfill the needs for promoting the performance of these materials were leads the all over the world's researchers to boost their efforts in producing a new and better materials. Composite materials, especially 'green composite' which can be found from the daily products fit well into this new paradigm shift.

There is a growing trend to use biofibers as fillers and reinforced in polymer composites. Their uniqueness has make them much attractive to manufacturers compared to existing monolithic material where polymer composite material are

much flexible during the fabrication processing, high in specific stiffness, low in thermal expansion but really high in strength and fatigue resistance. This century has witnessed ever-increasing demands for the utilization of plastics as important raw materials, more than 80% of which are thermoplastics. Biofiber reinforced plastics composites are gaining more and more acceptance in structural application [4].

On the other hands, natural fibers were introduced with lighter composited and offer lower cost compared to existing synthetics materials such as fiber glass reinforced composites. Natural fiber has produced a lighter composite. This is because the natural fiber itself has a lower density (1.2 – 1.6 gcm^{-3}) than the glass fiber (2.4 gcm^{-3}) [5]. Technological development connected with consumer demands has continues to increase demands on global resources, leading to major issues of material availability and environmental sustainability. Biofiber composite have become more sufficient as new compositions and the related processes have been intensively researched, developed and consequently applied. The petroleum crises made biocomposite significantly important and have become engineering materials with a very wide range of properties [4].

The use of bio-based plastics as reinforced matrices for biocomposites is gaining more and more attention day by day. The rapidly wider use of composite components in industries such automotive industry, construction industry, sports and leisure and other mass production industries, have lead to growing concern to focus on sustainable and renewable reinforced composites. Thus, the incorporation of reinforcements of fiber into composites affords a means of extending and improving the properties of the composites that meets the requirements of most engineering applications. As a result, these improvements will be associated with economic advantages. Hence, the demands for natural fiber reinforced composites have increased drastically for various commercial applications in the industrial sector [5].

Since natural fiber reinforced biocomposites has been developed, it has been used as automotive parts because of this material have good in mechanical properties beside a light weight properties. Therefore, it will help the users in reducing the consuming of petroleum oil since the price of oil is increasing from time to time. On the other hand, the automotive industry has already embraced this composite for

several years for the production of non-structural components and their use is predicted to constantly increase in a coming years. The upcoming efforts are aimed at developing 100 % structural composites with the utilizing of bio-source polymers as the matrix for natural fibers reinforcement instead of depending on the using of the synthetic fibers [6].

The adoption of PLA for automotive parts has been studied since PLA based automotive parts emit less CO_2 compared to other petroleum-based thermoplastics materials. PLA also provides good aesthetics, easy process ability in most equipment beside have a good strength. However, PLA has a brittleness properties and it needs modification for most practical application. One of the best idea to improve the mechanical and thermal properties of PLA is by introducing the fibers or filler material to that matrix [7].

1.2 OBJECTIVES

The objectives of this project are listed as below:

1. To produce PLA-based polymer composites with good mechanical and physical properties.
2. To study the effect of using chemical coupling agent on the bonding mechanism present in the PLA-based polymer composites.
3. To access the effect of dispersion on the tensile and impact properties of the degradable polymer composites.

1.3 SCOPES

The scopes of this project are listed as below:

i. Selection of materials and chemicals for the composites.
ii. Fabrication of biodegradable polymer composites test panels.
iii. Mechanical testing.
iv. Surface morphology.

1.4 PROBLEM STATEMENT

The production rate for worldwide automotive at this time is drastically increased. Therefore, the limited of petroleum resources will increase the petroleum-based products; price from year to year [8]. The growing environmental awareness and new rules and regulations are forcing the industries to seek more ecologically friendly materials for their product.

Living green has become a popular trend in the last twenty years and reducing oil consumption remains an important goal for the sustainably-minded today [9]. The highest of uses of crude oil is in the production of plastics. These plastics later end up in landfills where it takes years to break down or it will not entirely break down. As consequently, it will bring a negative impact towards the environmental. The becoming prices of petroleum-based plastics are predicted to be more expensive as oil prices continue to increase [10]. The economic and ecological drawbacks of petroleum-based plastics have pushed researchers to develop and investigate biodegradable plastics as an environmentally-friendly alternative.

A bio-based polymer as well as natural resource such PLA is ideal candidate to non-renewable petroleum based which is synthetic polymer. PLA is not only having degradability but PLA is the only natural resource produce at a large scale annually [11]. However, this type of material is brittle and has low tensile strength and impact properties in comparison to that of the petroleum-based polymer composites. Hence, this study aims to investigate the effect of dispersion on the mechanical properties of PLA-based polymer composites. [8].