SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure and Materials)"

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THE EFFECT OF INTERFACIAL BONDING IN THE MECHANICAL PROPERTIES OF DEGRADABLE POLYMER COMPOSITES

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This report submitted in partial fulfilment of the requirements for the award of Bachelor of Mechanical Engineering (Structure and Material)

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

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Special for

Ayah and Mama

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Bismillahhi-rahmani-rahim…

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ABSTRACT

This research focus on degradable polymer reinforced biocomposite that have received rapidly attention in term of their industry application. Researcher all around the world have done many research about the degradable polymer reinforced biocomposites because they highly confident that this biocomposites is able to complete with other materials. The materials chose are polylactic acid (PLA) as matrix and pineapple leaf fibre (PLAF) as the reinforcement material to fabricate the biocomposites. Tensile test as per ASTM D3039 was carried out tensile strength and Young's modulus at 36.62 ± 4.99 Mpa plain PLA, 68.13 ± 10.58 Mpa PLAF reinforced PLA and 1.62 GPa plain PLA ,2.80 Gpa PLAF reinforced PLA. Flexural test as per ASTM D790 carried out flexural strength and flextural modulus at 88.25 ± 10.71 Mpa plain PLA, 40.88 ± 13.21 MPa PLAF reinforced PLA and 1.65 ± 0.55 plain PLA, 2.58 ± 1.41 PLAF reinforced PLA. Impact test as per ASTM D6110 was carried out energy absorption at 0.35 ± 0.04 plain PLA, 0.92 ± 0.12 PALF reinforced PLA. Bonding mechanism present in the PLAF reinforced PLA biocompoistes is well adhered and compatible with the use of alkaline treatment. In other words, addition of fibre improved the interfacial bonding strength which results in harder and stronger composite materials.

ABSTRAK

Kajian ini member tumpuan kepada polimer terdegradasi biokomposit yang telah menerima perhatian yang mendadak di dalam pelbagai aplikasi di dalam industri. Para penyelidik di seluruh dunia telah melakukan banyak penyelidikan mengenai polimer terdegradasi biokomposit kerana mereka amat berkeyakinan bahawa biokomposit mampu bersaing dengan bahan bahan lain. Dua jenis bahan telah digunakan iaitu bahan polimer polylactic asid (PLA) dan gentian daun nenas sebagai bahan pengikat di dalam fabric bahan komposit bio ini. Ujian tegangan seperti ASTM D3039 telah dijalankan kekuatan tegangan dan Young' modulus bagi 36.62 ± 4.99 MPa plain PLA, 68.13 ± 10.58 MPa PLAF dimampatkan bersama PLA dan 1.62 ± 0.0.9 GPa bagi plain PLA,2.80 ± 0.44 GPa bagi PALF dimamatkan dengan PLA. Ujian lenturan seperti ASTM D790 menjalankan kekuatan lenturan dan lenturan modulus bagi 88.25 ± 10.71 MPa plain PLA, 40.88 ± 13.21 MPa PALF dimampatkan dengan PLA dan 1.65 ± 0.55 GPa plain PLA, 2.58 ± 1.41 PALF dimampatkan dengan PLA. Manakala ujian hentaman seperti ASTM D6110 telah dijalankan dan penyerapan tenaga yang terhasil adalah 0.35 ± 0.04 plain PLA dan 0.92 ± 0.12 PALF dimampatkan dengan PLA. Ikatan mekanisma hadir di PALF dimampatkan dengan PLA yang memperkukuhkan campuran komposit dan dipatuhi serta serasi dengan penggunaan cecair alkali. Dengan kata lain, tambahan serat meningkatkan kekuatan diantara ikatan di dalam bahan komposit dan ianya membuatkan lebih keras dan lebih kukuh.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In recents years natural fibre-reinfoced composites, emerging as one kind of benign composite materials, have attracted increasing attention from the standpoints of protection of the natural environments [1].These composites have been looked upon as an eco-friendly and economical alternative to glass fibre reinforced composites, owing to the good properties of the natural fibre such as renewability, biodegradability, low cost, low density, acceptable specific mechanical properties, ease of separation, and carbon dioxide sequestration [2]. Natural fibre-reinforced composites have increasing interest in many applications area including automobile, housing, packaging, and electronic products [3].

The composites from natural fibre and conventional polyolefin, that is, polypropylene and polyethylene, have been extensively studied [4]. However, combination of few factors such as shortage of landfill space, concerns over emissions during incineration, depletion of petroleum resources ; coupled with increasing environmental awareness have spurred the efforts to develop eco-friendly green composites or biocomposites plastics with the plant-derived natural fibres[5,6].

One of the most promising biodegradable polymers is poly (lactic acid) (PLA) which is produced from renewable resources, such as corn, sugar beet, wheat or sugarcane [7]. Due to its good biocompatibility, biodegradability, mechanical properties and light weight, PLA has been widely used in many aspects, such as medical applications and automotive parts [8, 9]. PLA has comparable mechanical properties to number of conventional plastics such as PP and PE, which makes it a reasonable substitute. However, PLA is a material with inherent brittleness and rigid behavior. These problems can be solved by copolymerization, blending with other polymers or adding plasticizer [10]. The commercial markets for PLA have increased substantially in recent years.

On the other hand, pineapple leaf fibre or known as PALF has recently been gaining a lot of attention as biomass-based filler, and it is well known as a cellulosic source with ecological and economical advantages, abundant, exhibiting low density, non-abrasiveness during processing, high-specific mechanical properties, biodegradability and cheap pricing [2,11].Over the past decade, cellulosic fillers have been of greater interest as they give composites improved mechanical properties compared to those containing non-fibrous fillers. In recent years, thermoplastic materials have been increasingly used for various applications.

As one of the promising biodegradable polymer at present, the cost of PLA is too high. This high cost has limited its commercial applications to some extent [17]. Therefore, it is considered that reinforcing PLA with pineapple leaf fibre is possibly an efficient way to enhance its mechanical properties and decrease the cost of PLA based material.

While being a very interesting pair with many potential applications, pineapple leaf fibre and PLA share an important problem, namely, the weak interfacial bonding between the polar fiber surface and the hydrophobic matrix [18]. The polymer adhesion to the fibre surface controls the stress transfer between the matrix and the reinforcing fibre. For these cases of polar fibre and hydrophobic matrices, poor mechanical properties can be linked to weak interfacial bonding. This problem of poor interfacial bonding needs to be solved, for good mechanical properties of composites and cost-efficiency of bulk production [19].

Fibre surface modification or use of compatibilizing agents is the key to solving these problems [20]. Compatibilizer, maleic anhydride grafted polymer has been widely studied and used, because the anhydride functionality of maleic anhydride grafted polymer reacts with cellulosic fiber's hydroxyl groups and esterification gives stronger links between the fibre surface and the matrix [21]. Whereas, the polymeric chain from the compatibilizer will diffuse into matrix and form entanglements with the matrix at the interphase. This results in a continuous link from the fiber to the matrix. Additionally, use of coupling agent is much more economical compared to fiber surface treatments as small amount of coupling agents used could produce desirable properties [22].

1.2 OBJECTIVE

The objectives of this project are listed as below:

1. To produce degradable polymer composites with good mechanical and physical properties.
2. To study the bonding mechanism present in the degradable polymer composites fabricated in the project.
3. To access the effect of interfacial bonding on the tensile and impact properties of the degradable polymer composites.

1.3 PROBLEM STATEMENT

Degradable polymer biocomposites such as PLA fibre reinforced biocomposites are finding increasing use in a wide range of applications [23]. However, this type of material is brittle in nature and has low tensile strength and impact properties in comparison to that of the synthetic polymer composites [24]. Hence, this research aims to enhance the mechanical performance of such biocomposites through understandings of the bonding mechanism between the polymer matrix and the fibre reinforcement [25].

1.4 SCOPE OF RESEARCH

The scope of this research are listed as below:

i. selection of materials and coupling agent for the composites.

ii. fabrication of biodegradable polymer composites test panels.

iii. mechanical testing

iv. physical testing

v. surface morphology

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION TO COMPOSITE MATERIAL

Composites can be defined as multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form". The weakness of this definition dwelled in the way that it permits one to group among the composites any mixture of materials without showing possibly its specificity or the laws which should to provide for it which recognizes it from other exceptionally dull, aimless mixtures.

Nowadays, quality to improve to high temperature or some other alluring quality, it is superior to both of the segments alone or drastically not the same as both of them. Beghezan characterizes as "The composites are compound materials which vary from amalgams by the way that the individual segments hold their attributes yet are so joined into the composite as further bolstering take good fortune just of their traits and not of their inadequacies", so as to acquire enhanced materials. Van Suchetclan clarifies composite materials as heterogeneous materials comprising of two or more strong stages, which are in private contact with one another on an infinitesimal scale. They can be likewise considered as homogeneous materials on a minute scale as in any parcel of it will have the same physical property [27].

A composites material is made by combining two or more materials on a microscopic scale to form a useful third material. Under the macroscopic examination the components can be identified by the naked eye. By using microscopic scale different materials can be combined such as in alloying metals, but the resulting material is for all practical purpose, macroscopically homogeneous for the example the components cannot be distinguished by the naked eye and essentially act together. If well designed the advantages is they generally show the best characteristics of their segments or constituents and frequently a few qualities that not one or the other constituent [27].

Properties that can be improved by forming a composite material are:

i. Strength
ii. Stiffness
iii. Corrosion resistance
iv. Weight
v. Fatigue life
vi. Thermal insulation
vii. Temperature- dependent behavior
viii. Thermal conductivity
ix. Attractiveness
x. Wear resistance

Composites materials have a long history of usage. Their exact beginnings are unknown, but all written history contains references to some manifestation of composite materials. More recently, fiber- reinforced, resin-matrix composites materials that have high strength to weight and stiffness to weight ratios have become important in weight sensitive application such as aircraft and space vehicles [27].

2.2 POLYMER MATRIX COMPOSITES

Most commonly used matrix materials are polymeric. The reason for this is twofold. When all is said in done the mechanical properties of polymers are insufficient for some structural purposes. Specifically their quality and solidness are low contrasted with metals and ceramics. These troubles are overcome by reinforcing different materials with polymers. Besides that the preparing of polymer matrix composites need not involve high pressure and doesn't require high temperature. Additionally equipments needed for manufacturing polymer matrix composites are simpler. Hence polymer matrix composites created quickly and soon got to be well known for structural applications. Composites are used because general properties of the composites are better than those of the individual components for example polymer/ceramic [26]. Composites have a greater modulus than the polymer components but aren't as brittle as ceramic. Two types of polymer composites are fiber reinforced polymer (FRP) and particle reinforced polymer (PRP) [26].

The most widely PMC that produced is polymer matrix containing glass fibers, whether continuous or discontinuous as enforcement. Glass is well known as the enforcement because this material easily molded to the high strength fibers in a liquid state. Much of its existence, and if necessary, this material can be fabricated on glass reinforced plastic economically by using various composite manufacturing techniques. Glass fibers are strong, and when implanted into the plastic matrix, the composite has a very high strength. One reason that makes fiberglass interesting is that when combined with plastic, resulting composites are very inert to chemical reactions and this enables it to operate in corrosive conditions [29].