EFFECT OF BONDING AGENT ON THE PROPERTIES OF PINEAPPLE LEAF FIBRE STARCH COMPOSITE

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in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled "Effect of Bonding Agent on the Properties of Pineapple Leaf Fibre Starch Composite" is the result of my own work except as cited in the references

Signature	:	.....
Name	:	Asyraf Kasyidi bin Mohd Shobi
Date	:	24 May 2017

APPROVAL

I hereby declare that I have read this project report 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 & Materials).

Signature	:.	.....
Name of Supervisor	:	Dr Mohd Zulkefli bin Selamat
Date	:	24 May 2017

DEDICATION

To my beloved family and fellow friends,

All your contributions, I will always keep in my heart.

Thanks a lot for the support and sacrificing.

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ABSTRACT

Nowadays, the usage of natural fiber to produce biodegradable composites has gained increasing interest due to their eco-friendly properties. Biodegradable composite can be defined as composite material or the combination between matrix and reinforcement used both materials from natural resources. Pineapple leaf fibre (PLF) is a waste product of pineapple cultivation. This fibre has potential as reinforcement fillers in thermosets, thermoplastics, elastomers or biodegradable matrix and exhibit excellent mechanical properties. One of biodegradable matrix is the mixture of starch (SH) and glycerol (GLY). The ratio of GLY has been vary from 10 up to 30% from total weight of mixture SH/GLY. The tensile strength of this mixture had been determine and the mixture of 70:30 (SH:GLY) shown the highest value of 0.734 MPa. Therefore, this matrix has been selected to produce composite of PLF/(SH/GLY) and the mechanical properties of this composite have been studied. The objectives in this study were to investigate the effect of fibre loading, addition of GLY as bonding agent and fibre treatment in PLF/(SH/GLY) composite by comparing the mechanical properties. The composite compositions are 50PLF/50(SH/GLY), 60PLF/40(SH/GLY) and 70PLF/30(SH/GLY) and has been fabricated through hot compression moulding in order to form composite sheet. The PLF fiber was treated used Sodium Hydroxide (NaOH) as treatment agent. The mechanical properties of the composite materials were analyzed through the tensile test (ASTM D 3039/D 3039 M-00), hardness test, density measurement and macrostructure analysis. All of the tests basically show improvement. Tensile strength shows increment of the value of 27.686MPa with the increasing of fibre loading. The same pattern also happen to the hardness and density measurement shows increment value of 55.0 in shore-D and 1.332g/cm3 of the result with the more composition of fibre in the composites. Therefore it can be concluded, the results showed 70PLF/30(SH/GLY) composite filled with treated fibre had higher in tensile strength, hardness and density.

ABSTRAK

Pada masa kini, penggunaan serat semula jadi untuk menghasilkan komposit biodegradable telah mendapat minat yang semakin meningkat kerana sifat mesra alam mereka. Komposit biodegradable boleh ditakrifkan sebagai bahan komposit atau kombinasi di antara matriks dan tetulang digunakan kedua-dua bahan-bahan dari sumber asli. Serat daun nanas (PLF) adalah produk sisa penanaman nanas. Serat ini mempunyai potensi sebagai pengisi penguat dalam termoset, termoplastik, elastomer atau matriks biodegradable dan mempamerkan sifat-sifat mekanikal yang baik. Salah satu matriks biodegradable adalah campuran kanji (SH) dan gliserol (GLY). Nisbah GLY telah berbeza-beza dari 10 sehingga 30% daripada jumlah berat campuran SH / GLY. Kekuatan tegangan campuran ini telah menentukan dan campuran 70:30(SH/GLY) yang dipaparkan nilai tertinggi 0,734 MPa. Oleh itu, matriks ini telah dipilih untuk menghasilkan komposit PLF/(SH/GLY) dan sifat-sifat mekanik komposit ini telah dikaji. Objektif dalam kajian ini adalah untuk mengkaji kesan loading serat, penambahan GLY sebagai ejen ikatan dan rawatan serat dalam PLF / (SH/GLY) komposit dengan membandingkan sifat-sifat mekanikal. Komposisi komposit adalah 50PLF/50(SH/GLY), 60PLF/40(SH/GLY) dan 70PLF/30(SH/GLY) dan telah direka melalui pengacuan mampatan panas untuk membentuk lembaran komposit. The PLF serat telah dirawat digunakan Sodium Hidroksida (NaOH) sebagai agen rawatan. Sifat-sifat mekanikal bahan komposit dianalisis melalui ujian tegangan (ASTM D 3039/D 3039 M-00), ujian kekerasan, pengukuran ketumpatan dan analisis Macrostructure. Semua ujian yang pada dasarnya menunjukkan peningkatan. kekuatan tegangan menunjukkan kenaikan daripada nilai 27.686MPa dengan meningkatkan serat loading. Corak yang sama juga berlaku kepada kekerasan dan pengukuran ketumpatan menunjukkan nilai peningkatan sebanyak 55.0 di shore-D dan 1.332g/cm^3 hasilnya dengan komposisi lebih serat dalam komposit. Oleh itu ia boleh membuat kesimpulan, keputusan menunjukkan 70PLF/30(SH/GLY) komposit penuh dengan rawatan serat mempunyai lebih tinggi dalam kekuatan tegangan, kekerasan dan kepadatan.

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LIST OF ABBREVIATIONS

PLF	Pineapple Leaf Fibre
SH	Starch
PLF/SH	Pineapple Leaf Fibre/Starch
SH/GLY	Starch/Glycerol
PLA	Polylactic Acid
NaOH	Sodium Hydroxide
HCl	Hydrochloric Acid
ASTM	American Standard Testing Method
GLY	Glycerol
PP	Polypropylene

LIST OF SYMBOLS

^{o}C	=	Degree Celsius
%	=	Percent
MPa	=	MegaPascal
GPa	=	GigaPascal
kN	=	kiloNewton
mm	=	millimetre
g	=	gram
cm^3	=	cubic centimetre

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Generally, bonding agents known as naturals, compounded or synthetic materials used to enhance the joining of individual members of a structure without employing mechanical jointing equipment or fasteners. These products are often used in various types of applications such as building construction, automotive, airbus and so on. For example in the application of building construction industry, the main types of bonding agents used are latex emulsions and epoxies. Furthermore, these two have their own mechanical properties and chemical properties as suitable bonding agents to be used for bonding the materials for construction process (Mailvaganam, n.d.). In biodegradable composite, regarding from that, those bonding agents are the main important elements, in order to analyze the strength of the materials involved in a certain project. Therefore, this project is focusing on the effect of bonding agents towards the composition ratio of two materials which is Pineapple Leaf Fibre (PLF) as reinforcement material and Starch (SH) as matrix material, in order to determine their mechanical properties. Bonding agent is known as additive, which is the material that can react with the composition of reinforcement and matrix, in order to increase the mechanical properties of the composites. Their presence towards the composition can affect the result on the mechanical testing whether it will show increasing or decreasing value of the composites sample. Bonding agent such as polylactic acid (PLA) and glycerol, GLY) can be available as their functions as plasticizers that can react with thermoplastic material such as starch and polypropylene (PP).

Reinforcement in a simplest word can be described as a material that will strengthen the structure. The reinforcement is made up of material or fibre. Nowadays, the natural fibres are increasingly used as reinforcement in polymer composite (Campbell, 2010). The reinforcement also can come from natural or made by human. There are other several types of reinforcement in industries such as synthetics fibre and natural fibre. The example of fibres that normally used in industries is glass fibre and carbon fibre. Glass fibre is well known as the combination made between steel sheet and zinc diecasting. For example in automotive industry, carbon fibre dominates as the main reinforcement that has low-cost composites. Furthermore, they has already reached its impressive performance level in automotive manufacturing process (Haruna et al., 2014).

There are a few examples of natural fibres such as sisal fibre, bamboo fibre, pineapple leaf fibre, hemp fibre and jute fibre. Nowadays, natural fibres such as sisal and jute fibre composite materials are being alternative natural fibres that can replace the glass and carbon fibers since the cost of glass fibre is quite expensive in market. Furthermore, the hardness and flexibility is good and compare to the glass fibre. The performance of natural fibre is improved remarkably due to the fact that the field of application is improved day by day especially in automotive industries.

Nowadays, natural fiber composites have gained increasing interest due to their eco-friendly properties. From the previous research that has been done by a researcher on natural fibre properties, the natural fibre has obtained positive results. This is due to the natural fibers such as jute, sisal, silk and coir are inexpensive, abundant and renewable, lightweight, with low density, high toughness, and biodegradable (Asim et al., 2015). Natural fibres such as jute have the potential to be used as a replacement for traditional reinforcement materials in composites for applications which require high strength to weight ratio and further weight reduction (Ashik & Sharma, 2015). Natural fibres are all kind of fibres that come from natural resources such as plant. The other word that can describe the natural fibres is a natural availability. The natural fibres that extract from the plants are actually obtained from the

certain parts of the plant such as leaf. Therefore, the strength of natural fibre will increase if it undergoes chemical treatment.

1.2 PROBLEM STATEMENT

Natural fibre composites are widely used in a few industries includes an automotive industry especially as an interior part. Currently in industries, normally for the type of natural fibre material used is synthetic fibre. Thus, natural fibres like sisal, banana, jute, oil palm, kenaf and coir has been used as reinforcement in thermoplastic composite industries for applications in consumer goods, furniture, low cost housing and civil structures (Munirah, Abdul Razak, & Hassan, 2007). Since the cost is much more affordable and it is a natural availability compared to the cost of glass fibres and carbon fibres, the industries try to harness the advantages of natural fibre composite. Nowadays, the automotive field tries to diversify the natural fibre in manufacture of a car bumper from kenaf while a car seat from coconut fibre. Furthermore, most of natural fibres are renewable, cheap and recyclable. Therefore in this project, the pineapple leaf fibre (PLF) is used as a reinforce material and starch (SH) as a matrix materials to produce PLF/SH composite. Thus the composite is biodegradable composite, which is consists of those two materials in order to keep strengthening the mechanical properties. Many advantages are associated with the use of biodegradable composite, including low cost, abundance, low density, high specific properties and lack of residues upon incineration (Sahari & Sapuan, 2011). Besides, it is also a solution to maintain the sustainabale development of economical and ecological technology.

The current mechanical properties of PLF/SH composite used is might lower based on their analysis in mechanical testing. Hence, one of the alternative solution to increase the mechanical properties of PLF/SH is through added the bonding agent (1 up to 10 % from the total weight of the composite). The presence of bonding agent is to improve the interface between the matrix material and reinforcement. One of the materials can be used as bonding agent is glycerol. GLY can be mixed with SH before this mixture can be used as matrix in

PLF/(SH/GLY) composition. In order to determine the effectiveness of bonding agent several mechanical tests will be carry out such as tensile test, hardness and flexural test. Therefore, the mechanical properties of PLF/SH composite will be performed in order to investigate their actual mechanical properties. On the other hand, composite also have good potential to be used as an interior part of automotive but its potential has not been explored yet.

1.3 OBJECTIVES

There are two goals which are listed to be achieved on this project:

1. To determine the effect of GLY as binder loading on the physical and mechanical properties of SH/GLY composition.
2. To study the effect of PLF loading on the properties of PLF/(SH/GLY) composite.

1.4 SCOPE OF PROJECT

This research studies the effects of bonding agent loading on the mechanical properties of PLF/SH composite which will be carrying out. The various ratio of bonding on SH/GLY composition are being selected and determine the physical and mechanical properties. After that the composite PLF/(SH/GLY) will be fabricated through hot compression moulding with the ratio of composition in the composite is fixed at, 70:30, 60:40: 50:50. An alkaline treatment will be conducted to extract thin PLF bundles and enhance the PLF properties before the formation process of PLF/SH composite by using hot pressing machine. The mechanical properties of PLF/SH composite is need to be determined by using tensile test, hardness test, density measurement and macrostructure analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Natural fibres composites are widely used in industry in order to produce a new product since it is an environmental friendly. Nowadays, the industrial automotive is trying to use the natural fibres composites especially in the making of interior part as shown in Figure 2.1 below. This is highlighting on their advantages which are low cost and weight, also can prevent from damage towards processing equipment and great in mechanical properties (Sanjay et al., 2016). Natural fibres also can be defined as substances that come from agricultural residues. Thus, they can be used as the reinforcement with biodegradable polymer composites as a development in order to obtain useful products in industries.

Figure 2.1: Application of natural fibres in automotive industry (Farsi, 2000)

The combination of the natural fibres reinforced with biodegradable polymer composite also can provide an alternative way in order to solve the problems that associated with agriculture crop residues. All of thems are being produced everyday and they are being obtained in a large amount of quantity. Therefore, the reinforcement of natural fibres and biodegradable composite can prevent from negative effect on the environment due to the air pollution of the residues.

2.1.1 Biodegradable Composites

Biodegradable composite can be defined as composite material or the combination between matrix and reinforcement of natural fibres. These kinds of materials have their own function which keep strengthening the properties of the matrix that was used, but always providing biodegradable compatibility. It is also known as composite material made from natural fibre and polymer matrix derived from petroleum such as polylactic acid (PLA), cellulose and thermoplastic starch (Sahari & Sapuan, 2011). Thus, the matrix part of the biodegradable composite can be classified into two parts which are fully degradable and partly degradable as shown in Figure 2.2 below:

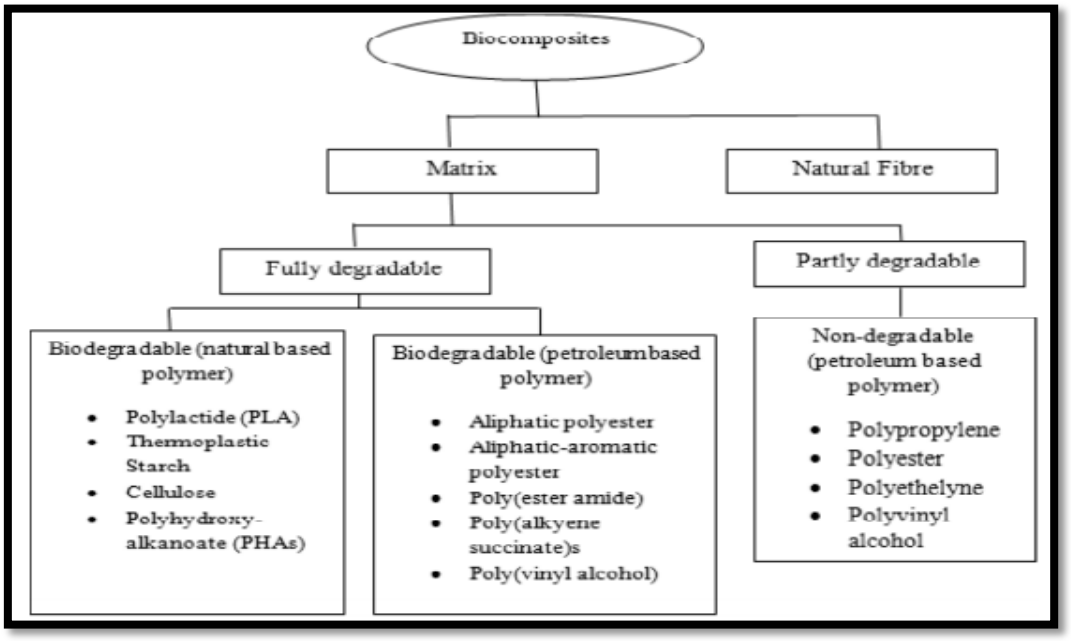

Figure 2.2: Biodegradable composite (Sahari & Sapuan, 2011)

For more specific, the combination of the composite material is being used in one of the world's major palm oil producer in Malaysia, where the natural fibre of oil palm has been successfully compounded with thermoplastics such as PLA in order to produce biodegradable composites. The forming biocomposite which is lignocellulose fibre is a renewable material and also can increased the surface roughness of the fibre by the removal of hemicellulose and surface impurities (Schaschke & Audic, 2014).

2.2 MATRIX (BINDER)

There are many types of materials used as matrix in composites. Therefore, in order to combine the matrix with the fibre, it must be in the suitable type of the matrix. This is because the combination of the fibre with the appropriate matrix will form a very good strength property. A good matrix has many advantages to the reinforcement such as can prevent the natural fibre of abrasion and defects in surface, also acting as a binder to the fibre used in composition (Verma et al., 2012).

The types of matrix that normally used in composites are metal matrix and polymer matrix. However, these two matrices have their own characteristics that could affect the performance of the composition formed. For more specific, metal matrix has good strength at higher temperatures, but high in density that can cause lower specific mechanical properties if compared with polymer matrix (Verma et al., 2012). However, the matrix used in this project is thermoplastic starch which is included in polymer matrix. The matrix will support load among the reinforcements since the reinforcements are discontinuity.

2.2.1 Starch

Starch is classified in thermoplastic type, with also included as green composite based on their compositions, preparations and properties. Because of that, the characteristics of the starch have gained many interests due to its properties as the material of environmental

friendly and biodegradable renewable sources. However, the research shows that the application of starch can be further expanded, and can be developed more in order for wider usage. The starch brings many advantages especially in composites. This is because starch is naturally form in much quantities, can be renew and cheap in market (Wattanakornsiri & Tongnunui, 2014).

Before forming into the thermoplastic polymers, there are various sources of starch that has been used such as corn starch, tapioca starch, rice starch and wheat starch, which need to be bonded with addition of plasticizers in high temperature and shearing force. The purpose of this converting process is to obtain the lower friction between the molecules of the starch. The example of plasticizers that usually used is water and glycerol (Wattanakornsiri & Tongnunui, 2014).

In the chemical properties of starch, the starch contains two main elements which are amylose and amylopectin as shown in the presence of chemical structure in Figure 2.3 and Figure 2.4. These kind of elements can be hydrolyzed the compound into glucose. Initially, the starch is in crystalline form. The starch is normally need to be gelatinized which the intermolecular bonds molecules of starch is break by the water and heat, that make the hydrogen bonding sites is reduced and irreversibly dissolves the starch granules in water (Wattanakornsiri & Tongnunui, 2014).

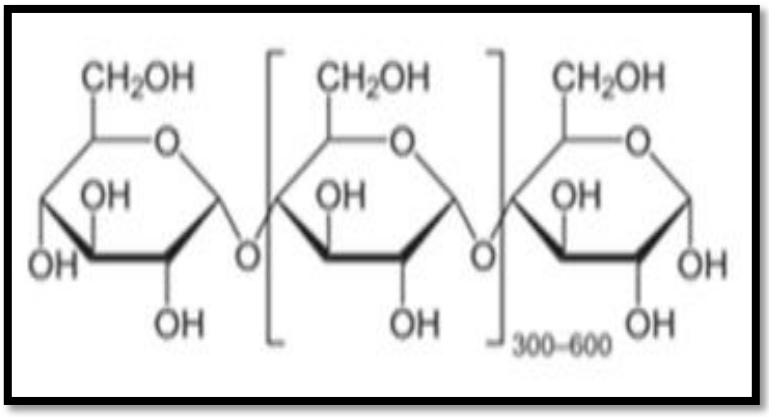

Figure 2.3: Chemical structure of amylose. (Wattanakornsiri & Tongnunui, 2014)