TITLE

FIBER CHARECTERISATION OF OIL PALM EMPTY FRUIT BUNCH (OPEFB): ENZYMME TREATMENT AND ULTRASOUND TREATMENT

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LIST OF ABBREVIATIONS

JAS	Japanese Agriculture Standard
OSB	Oriented Strand Board
OPEFB	Oil Palm Empty Fruit Bunch
UTM	Universal Tensile Tester
ASTM	American Standard Testing Method

LIST OF SYMBOLS

˚C	Degree Celsius
%	Percentage
MPa	Mega Pascal
USD	United States Dollar
RM	Ringgit Malaysia
Tons	Tones
$	Dollar
pH	Power of Hydrogen
˚F	Degree Fahrenheit
g/cm^3	Gram per centimeter cube
µm	Micro meter
mm	Millimeter
M	Molarity
V	Volume
mL	Milli-Liter
g	Gram
h	Hour
cP	Centipoises
wt.	Weight
s	Second

FIBER CHARECTERISATION OF OIL PALM EMPTY FRUIT BUNCH (OPEFB): ENZYMME TREATMENT AND ULTRASOUND TREATMENT

ABSTRACT

Oil Palm Empty Fruit Bunch (OPEFB) is a major waste which is generously abundant in Malaysia. As the age of composite material is at hand, much effort has been put into research of new fiber based fillers for polymeric composite material. This research focuses on characterizing the abilities of laccase enzyme treated OPEFB with further ultrasound treatment to function as a fiber filler for polymeric materials. The end result is expected to show whether or not the modified fiber has an augmented property that could be used in application to further strengthen the structural properties of monolitich materials to become superior composites. Three particular methods of testing were chosen, which tensile test was using Universal Tensile Machine (UTM), lignin test to calculate the amount of removed lignin and water absorption test. At the end, it is clear that the usage of enzyme causes a severe fracture in the lingo-cellulosic backbone of the fiber and henceforth reduces certain aspects of its mechanical properties.

PENCIRIAN GENTIAN BUAH TANDAN MINYAK SAWIT KOSONG (OEFB): RAWATAN ENZIM DAN RAWATAN ULTRASOUND

ABSTRAK

Buah Kelapa Sawit Tandan Kosong (OPEFB) adalah sisa utama yang banyak terdapat di Malaysia. Disebakan era bahan komposit adalah berdekatan, banyak usaha telah dicurahkan ke dalam penyelidikan pengisi gentian baru berasaskan bahan komposit polimer. Kajian ini memberi tumpuan kepada mencirikan kebolehan OPEFB yang dirawat enzim laccase dan ultrasound untuk berfungsi sebagai pengisi serat untuk bahan polimer. Hasilnya dijangka untuk menunjukkan sama ada atau tidak serat yang diubahsuai mempunyai kebolehan yang boleh digunakan dalam pengunaan untuk mengukuhkan lagi sifat-sifat struktur bahan monolitich untuk menjadi komposit unggul. Tiga kaedah ujian dipilih, iaitu ujian ketegangan menggunakan Universal Tensile Machine (UTM), ujian lignin untuk mengira jumlah lignin yang dikeluarkan dan ujian penyerapan air. Pada akhirnya, ia adalah jelas bahawa penggunaan enzim menyebabkan tulang belakang ligno-cellulosic serat rekak dan seterusnya mengurangkan aspek-aspek mekanikal tertentu serat

CHAPTER 1

INTRODUCTION

1.1 Background of study

Material engineering is a major field of interest in the field of chemical engineering as the study of materials and their application is extremely vital towards further development in this growing era. Increasing amount of research are being conducted in this field to produce a relatively good substitute towards naturally occurring materials which are unrenewable such as metals.

With this in mind, composites have become the major choice for materials in the past decade surpassing monolitich materials such as ceramic, polymers and to a certain extent even metals According to Paul Wambua, Jan Ivens and Ignaas Verpoest (2003), fibre based composites, namely fibre reinforced polymeric materials are the major drivers of the material industry overtaking most kind of monolitich materials in the past decade. These composites such as carbon composites, aramid and glass fibre reinforced polymers are monopolising most major industries which are inclusive of aerospace, leisure, automotive and construction just to name a few.

Diving deeper into this field it is notable that the major kind of composite that is in demand is the glass fibre reinforced composite. In a study conducted by Paul Wambua et. al.(2003), it was found out that, this was majorly due to the cost effectiveness of glass fibre reinforced polymers which was relatively cheaper than those of carbon composites and aramid respectively. On the other hand, glass fibre reinforced polymers are also dominating as they are able to deliver the desired mechanical properties that are required in the industry.

Glass fibres though possessing favourable qualities that are applicable in the industry still exhibit major drawbacks namely their inability to be recycled, renewed and biodegraded as well as its relative higher density compared to natural fibres and stability in the neutrality of Carbon Dioxide. These drawbacks of glass fibres are fortunately not present in naturals fibres which makes natural fibres a new substitute for glass fibres. As mentioned by Paul Wambua et. al.(2003) natural fibres will act as a good substitute for glass fibres with reference to one major factor that is Carbon dioxide neutrality, meaning that natural fibre do not produce or release Carbon Dioxide gas when decomposed in manners such as burning in comparison with glass fibres. Significant attempts have been made to replace glass fibre reinforced composites with natural fibre substitutes (Larbig H, Scherzer H, Dahlke B, Poltrock R., 1998).

Natural fibres generally refer to natural cellulose based fibres which are abundant naturally in plants and are currently used in the reinforcement of plastics (both thermosetting and thermoplastic) (A.K. Bledzki, J. Gassan, 1999). Further in their study, A.K. Bledzki and J. Gassan mentioned that the usage of natural fibres as reinforcement for composites is undergoing a new birth, in a sense meaning that in the past this technology was already present but not celebrated. The new era welcomes the usage of natural fibre reinforced composites mainly in the automotive and packaging industries. The significant natural fibres that are usually used are jute fibres which have been a successful substitute for glass fibre in many polymeric materials such as Polyvinyl chloride (PVC) and Polypropylene hybrid composites.

There has been a growing interest in utilizing natural fibres as reinforcements in polymer composite for making low cost construction materials in recent years. Natural fibres are prospective reinforcing materials and their use until now have been more traditional than technical. They have long served many useful purposes but the application of the material for the utilization of natural fibres as reinforcement in polymer matrix took place quite recently (Joseph et al. 1999). Many studies had been carried out on natural fibre likes kenaf, bamboo, jute, hemp, coir, sugar palm and oil palm (Arib et al. 2006; Khairiah & Khairul 2006; Lee et al. 2005; Rozman et al. 2003; Sastra et al. 2005). The advantages of these natural resources are low weight, low cost, low density, high toughness, acceptable specific strength, enhanced energy recovery, recyclability and biodegradability (Lee et al. 2005; Myrtha et al. 2008; Sastra et al. 2005). Natural fibre can be divided into four different types which are leaf, bast, fruit and seed (Khairiah & Khairul 2006; Wollerdorfer & Bader 1998).

The major source of edible oil is oil palm (Elaeis guineensis) which is extracted from its fruits. One of the significant problems in the palm fruit processing is managing of the wastes generated during the processes. It was estimated that more than two million tonnes (dry weight) of extracted oil palm fibre is generated annually in Malaysia (Tan et al. 2007). Currently, there are many studies on the incorporation of empty fruit bunch (EFB) into polymers to gain a cost reduction and reinforcement by various workers. Ridzuan et al. (2002) reported that it is possible to produce medium density fibreboard (MDF)from EFB fibre and can improve the MDF performance by a pre-treatment to remove the residual oil. Rozman et al. (2004) stated that the employment of EFB in mat form has produced polyurethane-empty fruit bunch (PU-EFB)composites with acceptable properties where composite with isocyanate treated fibres have a superior tensile and flexural properties than those without treatment. It is found that highest shore D hardness, impact and flexural strengths and better matrix to EFB fibres (Khairiah & Khairul 2006). According to Rozman et al. (2001), there was a reduction of flexural and tensile strengths from the incorporation of EFB and glass fibre (GF) into polypropylene (PP) matrix. Kalam et al. (2005) found that increasing fibre volume ratio from 35 vol% to 55 vol% for oil palm fruit bunch fibre (OPFBF)/epoxy composite reduced the tensile strength of the composite and increased the Young's modulus. Composite of Arenga pinnata fibre reinforced epoxy showed that the 10 wt.% woven roving fibre has the highest value of flexural strength test (Sastra et al. 2005). Sapuan et al. (2006) has studied the mechanical properties of woven banana fibre reinforced epoxy composites and found that the composites can be used for the household utilities. Therefore, the purpose of this work is to study and evaluate the tensile and flexural properties of short random oil palm fibre reinforced epoxy (OPF/epoxy) composites. The composites were fabricated using hand layup Techniques and four different ratios were prepared. water resistance are exhibited in biocomposite board with blending ratio of 35:65 of PU.

In a nutshell, fibre reinforced polymeric composites are the new leaders in material technology and the usage of natural fibres to replace the currently used glass fibres is an extremely beneficial effort. As further research is conducted in the usage of bamboo fibre reinforced composites its essential that this research be specified to more common use such as PVC composites.

1.2 Problem statement

Currently, due to the monopoly of composites within the material industry, it has become a primary concern among most manufacturers to produce 'miracle material' which, would possess, to certain extent most of the desired qualities that is needed ranging from durable mechanical properties such as tensile strength and hardness, till environmentally friendly properties such as biodegradability and recycle ability.

The usage of composites which are reinforced by the usage of glass fibres is able o only satisfy one of these two main criterions, which is the presence of excellent mechanical properties. Majorly due to the fact that glass fibres are synthetic by nature they tend to have major drawbacks, most commonly which are their inability to be biodegraded, renewed or recycled.

Also, glass fibre reinforced composites tend to exhibit other kinds flaws due their synthetic nature such as relatively higher density in comparison with natural fibre reinforced composites as well as the necessity of a higher production cost, due the fabrication requirement of synthetic glass fibres. Carbon dioxide stability also fall within the undesired capabilities of glass fibres, as they tend to exhibit instability in the neutrality of Carbon Dioxide.

1.3 Research Objectives

This research primarily focuses on collecting data in regard to the applicability of enzyme treated and ultrasound treated Oil Palm Empty Fruit Bunch (OPEFB). Through this research it is aimed to understand and discover whether the usage of laccase as treatment enzyme as well as further treatment of OPEFB fiber with ultrasound would be able to improve the mechanical properties of the fiber in application as a filler for usage in polymeric composites.,

1.4 Scope of Study

Our scope of study will be classified under two major categories which is the preparation of the sample material and the testing of the material. Under the scope of preparation, two aspects would be considered, which is the effects of enzyme treatment as well as further treatment using ultrasound, would significantly improve the characteristics of the OPEFB fiber. The enzyme which would be used in this study is the fungal enzyme commonly known as laccase enzyme.The other area of interest which would be studied, is the testing of the prepared sample material. The tests that would be conducted are water uptake test, tensile test and lignin test.

1.5 Significance of Study

The current industrial sector focuses on two major factors which are the economics of products and the environmental benefits that the particular product offers. Hence, through the production of polymeric composites which are reinforced by natural fibres both this criterions will be achived. As proven from certain research conducted previously, natural fibres such as hemp and bamboo are able to further elevate the mechanical properties of the polymers as well as posses the natural ability to biodegrade and can be renewed and recycled. This would thus create a product which would be suitable for both practical use and environmental aid.

1.6 Conclusion

As a conclusion, this chapter has discussed an overview of the overall usage of the research that would be carried out which is inclusive of the reasons behind the research to be conducted as well as the benefits that would be provide by the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will be discussing about the overall research with regards with previous studies and experiments that have been conducted as an analysis. The information gained from different papers will be used as guidance in further understanding the detailed improvement that was achieved from the usage of laccase enzyme as a structural modification agent for Oil Palm Empty Fruit Bunch (OPEFB). It will also look into the aspect of the usage of ultrasound treatment to further change the properties of the experimented OPEFB. Besides that, we will also take a look into the abundance of OPEFB and the usage of natural fiber as fillers for composites.

2.2 Biomass and Bioenergy

2.2.1 Biomass Capability in Malaysia

Biomass defined as full range of plant and plant derived materials. Biomass also describe as a renewable fuel resources which cover almost any biologically degradable fuel from farmyard manure through industrial liquid effluents and solid waste, agro industrial and forestry waste. Commonly, biomass from plant comprised of cellulose, hemicellulose, and lignin. Nowadays, biomass from plant are the main resources which renewable and sustainable resources available in production of ethanol and other chemicals. Biomass contributes approximately 14% of the total global final energy demand. In is included for cooking, heating and electricity.

In Malaysia, oil palm is a main resource in production of edible oil which is important in food industry and as a daily usage. According to Pusat Tenaga Malaysia, (TM 2005), the waste from oil palm consist fiber, empty fruit bunch, shell, POME, and trunks. The waste from palm oil are higher than waste from other plants such as rice, sugarcane and wood. In 2003, biomass from oil palm consists 14 million tons of oil palm empty fruit bunch; 8 million tones palm kernel shell and 5 million tones mesocarp fiber.

2.2.2 Bioenergy in the world context

Biomass has a significant role to play in solving the world's energy needs. Biomass combustion is carbon neutral. The carbon dioxide released in combustion is recycled by trees and crops which may provide fuel for the future. By utilizing biomass as a fuel instead of a non renewable fossil fuel, the net carbon dioxide released into the atmosphere is deemed to be reduced. Biomass is capable of replacing fossil fuels in order to provide electrical power and generate heat in those areas where it is abundantly available. In order for biomass to be widely accepted, overall cost factors have to be fully analyzed. Comparing the use of biomass to other established fossil fuels has to be taken into account, together with the investment and infrastructure already in place. Incorporating bioenergy into a holistic framework which assesses the total cost including the environment shows that biomass can be a competitive energy source (Shell, 1999).

2.3 Fibers as Filler for Composite Materials

2.3.1 Fiber Reinforced Composites

Composites are materials composed of more than one kind of monolitich material. In this part, we shall be looking at fiber reinforced polymeric composites in which the fiber will be embedded in the polymer matrix.

The major kind of fiber that is being currently applied in the composite production industry is the glass fiber. According to Paul Wambua, Jan Ivens and Ignaas Verpoest (2003) it is advisable to use glass fiber reinforced composites in comparison to the usage of other kind of composites such as aramids and carbon based composites is majorly due to the cost effectiveness factor. Paul Wambua et al. (2003) further explain that in comparison to the usage or carbon based composites and aramids, glass fiber reinforced composites are relative cost friendly towards the manufacturers.

As the function of the fiber is to further increase the mechanical properties of the matrix material which in this case would be the polymeric composite, hence it is undeniable that this target is actually achieved based on the results that were presented by Rahul A. Khan et al. (2011). In their findings they were able to prove that there is a significant improvement in most mechanical properties of the PVC material. To show a clear picture the tensile properties and bending properties of a standard PVC film and a fabricated PVC film embedded with E-glass fiber are compared. Before the embedment, the PVC film had a tensile strength (TS) of about 35 MPa and a bending strength (BS) of43 MPa which rose to nearly double the actual amount after the embedment of the E-glass fiber with a TS and BS of 70 MPa and 72 MPa respectively. Hence this proves that the basic idea of fiber embedment would increase the desired properties of the monolitich material.

2.3.2 Natural Fiber Reinforced Polymeric Composites

This part will be discussing further in depth regarding the drawbacks of glass fiber reinforced composites and the advantages of substituting them with the alternative which is the application of natural cellulose fiber based reinforcements.

In their study A.K. Bledzki and J. Gassan (1999) classify natural cellulose fiber into certain subdivisions such as plant based and poultry based as well as mineral based. The presence of fiber within plants in the form of cellulose and hemicelluloses gives most plant their natural durability which is a desired quality that is required by many fields in various industries.

As discussed in the previous chapter it is notable that the usage of glass fiber which is widespread in the material field still contain certain drawback such as the inability of renewability, recyclability and biodegradability of glass fibers with addition their physical properties such as high density with comparison to natural fibers as well as ability to withstand abrasion. In their findings Paul Wmbua et al. (2003) states that these shortcomings influences the glass fiber to be exploited by the natural fiber as natural fibers do not exhibit any of this distinct characteristics. Another major argument in their study suggests that it is also vital to consider the risk factor in the usage of glass fiber as it has no neutrality towards Carbon dioxide. In their findings, they were able to show that hemp (a kind of natural fiber) reinforced composite had a TS of 85 MPa which is very much higher compared to the TS of a glass fiber reinforced composites of similar volume fraction which was 32 MPa. There were 7 different natural fibers which were used to run the experiment in which most of the composites which were reinforce with natural fibers had a TS of 30 MPa and above with exception to the coir fiber reinforced composite (TS of 10 MPa).

On the other hand, a separate study that was conducted by Rahul A. Khan et al. (2011) gives a different picture of the whole scenario. In their research Rahul A. Khan et al. state that the E-glass reinforced PVC composite exhibit far greater mechanical properties than that of jute fiber reinforced PVC composites. Both the PVC composites were fabricated in the form of PVC films with embedded E-glass fibers and jute fibers respectively and put through testing. The end result showed that even though jute fiber reinforced PVC film has a significant improvement in comparison with the standard PVC film, it still lost out to the E-glass fiber reinforced PVC film. Taking certain data from the test to project a better understanding of the scenario shows that, E-glass fiber reinforced PVC has a TS of 65 MPa with jute fiber reinforced PVC having a TS of 45 MPa. Regardless of that both materials exhibited the same amount of impact resistance with impact strength of about 28 t0 30 kJ/m^2.

As depicted, it is clear that usage of natural fibers in polymer composites does not present much improvement in mechanical properties compared to that of glass fiber reinforced composites, with that as a contributing factor both Paul Wambua et al. (2003) and A.K. Bledzki and J. Gassan (1999) agree that this properties of natural fiber reinforced composites will be suitable for usage in specific areas such as automotive industry and packing industry.

2.4 Oil Palm Empty Fruit Bunch

2.4.1 Oil Palm Empty Fruit Bunch Abundance in Malaysia

Malaysia is today the world' s largest producer and exporter of palm oil, accounting for some 60% of world production. However, it is facing serious