Faculty of Engineering

CHEMICAL TREATMENT IDEAL SOAKING TIME OF EMPTY FRUIT BUNCH (EFB) POLYMER COMPOSITE TO ACHIEVE HIGH MECHANICAL PROPERTIES

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Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)
2008

Chemical treatment ideal soaking time of empty fruit bunch (EFB) polymer composite to achieve high mechanical properties

By

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This project is submitted in partial fulfillment of the requirement for the degree of
Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)

Faculty of Engineering
UNIVERSITY MALAYSIA SARAWAK
2008

Dedicated To,

My Loving Family and My Love Ones…

ACKNOWLEDGEMENT

I would like to take this opportunity to give my acknowledgement to everyone that helps me with their guidance and sincerity throughout this completion of my final year project.

Here by, I would like to express my greatest appreciation to my project supervisor, Madam Mahshuri bt Yusof for her assistance, valuable guidance, motivation, encouragement and advices in conducting the research and writing this report.

I would like to express my thanks to my beloved parents and my beloved ones for their morale support and blessing throughout this project. Also thanks to my friends for their understanding and passion to help me to complete my final year project.

Last but not least, I also like to state my greatest gratitude to the lab assistant, technicians and supporting staff for their contribution.

ABSTRACT

Palm oil empty fruit bunch natural fibre reinforced unsaturated polyester composite have been fabricated in random orientation with 10% constant fibre volume fraction. The experimental study was taken to determine the ideal soaking time of fibre during chemical treatment process with two different chemical agents (NaOH and Silane) to achieve highest value of Ultimate tensile strength, Modulus of elasticity and Energy Absorbed at Break. The specimens were categorized according to time frame for each chemical agent. Tensile test has been carried out to the entire specimen according to ASTM 3039-76 in order to investigate the behavior of the composite under tension. The Testometric machine been used to carried out this testing. The effect of the surface treatment by the chemical agent differs from one soaking time to another. The chemical treatment process purpose is to increase the roughness of the natural fibre for a better impregnation with matrix. The result showed that the ideal time to achieve highest ultimate tensile strength is at 4 days for NaOH and 2 minutes for Silane. The ideal time to achieve highest Young’s modulus value is at 3 day’s for NaOH and 5 minutes. Soaking time 2 day’s for NaOH and 15 minutes for Silane are the ideal time to achieve highest energy at break value.

ABSTRAK

Komposit poliester tidak tepu yang diteguhkan dengan serat semulajadi tandan buah kosong kelapa sawit telah dibentuk dalam orientasi rawak dengan 10% bahagian isipadu serat tetap. Kajian eksperimen ini diambil untuk menentukan tempoh merendam yang unggul bagi serat semasa proses rawatan kimia menggunakan dua agen kimia yang berbeza (NaOH dan Silane) untuk mencapai nilai tertinggi kekuatan ketegangan akhir, modulus keanjalan dan tenaga semasa putus. Spesimen-spesimen ini dikategorikan mengikut tempoh masa bagi setiap agen kimia. Ujian ketegangan telah dijalankan ke atas semua spesimen mengikut ASTM 3039-76 bagi menyiasat kelakuan komposit di bawah keadaan tegang. Mesin Testometrik digunakan bagi menjalankan ujian tersebut. Kesan rawatan permukaan oleh agen kimia berbeza daripada waktu merendam yang berlainan. Proses rawatan kimia bertujuan untuk meningkatkan kekasaran serat semulajadi bagi kekukuhan yang lebih baik dengan matriks. Keputusan menunjukkan bahawa waktu yang unggul untuk mencapai nilai tertinggi kekuatan ketegangan akhir adalah 4 hari untuk NaOH dan 2 minit untuk silane, manakala untuk mencapai nilai modulus Young tertinggi adalah 3 hari bagi NaOH dan 5 minit bagi Silane. Waktu merendam 2 hari bagi NaOH dan 15 minit bagi Silane adalah waktu unggul untuk mencapai nilai tenaga semasa putus yang tertinggi.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The oil palm industry started 80 years ago in Malaysia. Today it covers the large portion of plantation sector in Malaysia. The total area of this sector is over 2.65 million hectares, producing 10 million tonnes of palm oil annually. Only 10% of the total biomass produced in the plantation consists of oil, the remaining 90% of the production consists of huge amount of lignocellulosic material such as oil palm fronds, trunks and empty fruit bunches (EFB). According to Sirim berhad Malaysia, 7.0 million tonnes of oil palm trunks, 26.2 million tonnes of oil palm fronds, and 23% of Empty Fruit Bunch (EFB) per tonne of Fresh Fruit Bunch (FFB) processed in oil palm mill annually. [1]

Based on the statistics, Malaysia therefore has a great potentional to turn the residues into valuable product. Recent report shows that the mesocarp fibre and shell are used in boiler to produce steam and to generate power. Whereas, empty fruit bunches are mainly incinerated to produce bunch ash to be distributed back to the field as fertilizer. The burning of

EFB with conventional methods create environmental problem such as air-pollution and is prohibited by the Environment Protection Act. Nevertheless, this reduces especially the EFB can be change to valuable product using fibre based (natural fibre) composite rather than burning the EFB. [1]

Natural fibre-reinforced composites with improved strength and toughness rose from the use of agro-industrial residues as reinforcement of polymer matrices, eventually more competitive from an economic point of view compared to the original plastic material. The technical studies suggested that natural fibre composites have the potential to compete with composites reinforced with inorganic fibres. The natural fibres have many advantages such as high modulus, ease of fibre surface modification and low density. Furthermore, natural fibres are highly hygroscopic, which tend to absorb water until the equilibrium state is reached, so that its complete dehydration is difficult to reach. Therefore, at the same time as the low cost of the natural fibres is one of their main advantages against the use of inorganic fibres. [2]

1.2 Empty Fruit Bunch(EFB) fibre

The EFB (Figure 1.1) constitutes about 20% to 22% of the weight of fresh fruit bunches and contains 30.5% dry matter, 2.5% oil and 67% water. An approach towards adding value to EFB is by chemical modification.EFB, like other woody products is made up of cellulose, lignin and hemicelluloses. The EFB has the highest fibres yield is the only material commercially utilized for fibre extraction compared to other oil palm residues. [3]

Figure 1.1: Empty Fruit Bunch (EFB)

According to Sirim Bhd Malaysia, many researches involve in R&D for EFB such as PORIM and FRIM. This researchers set up a committee to identifies the characteristic of EFB fibre. Characteristically EFB fibres are clean, biodegradable, compatible and very suitable for the manufacture of car seat, composite panel product and mattress. The impurity of the EFB fibre is critical element in producing high quality fibres. Impurities means the spikes, aggregates or fibre strands, calyxes, any dust or fine particles and parenchyma of EFB.

According to standard MS 1408:1997 (P) (Specification for oil palm empty fruit bunch fibre) maximum levels of impurities allowed is at 15%.The final EFB fibre characteristic is the oil content of the fibre. The presence of a important percentage of remaining oil possess a main problem is that, it will react with the moisture content, thus giving rise to rancidity and ultimately fungal growth. [1]

1.3 Scope and objective

The main objective of this study is to investigate the ideal soaking time of empty fruit bunch (EFB) polymer composite to achieve high mechanical properties. In this study, the effect of tensile load with different soaking time will also be investigated.

To achieve these objectives, the fibre from empty fruit bunch was soaked into two different surface treatment agent; those are Silane A174 and sodium hydroxide (NaOH). The volume fraction of the fibre is set to be constant for every different soaking time. Once the composite specimen with different soaking time is ready, tensile test were carried out according to ASTM-D3039-76 which is a standard test method for tensile properties of polymer matrix composite material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on researches that have been done by engineers and scientist regarding to the objective and scope of this project. This includes type of fibres, type of resins, tensile test theory, the effect of coupling agents, and effect of adhesion bonding in interface.

2.2 Type of Fibres

Composite materials are light-weight, high strength to weight ratio and good stiffness properties which potential replacing other conventional material like metal. Natural composite reinforced with jute, sisal, coir, empty fruit bunch, banana and lot more primarily cut down the cost of raw material.

Natural fibres are subdivided according to their respective origin. Some are from animals, plants and minerals. Animal fibres consists of proteins such as hair, silk, and wool where else the plant fibres include bast fibre, leaf fibre, seed, fruit, straw and grass fibres. [4]

2.2.1 Natural fibre

Natural fibres are naturally formed fibres where the cellulose fibrils embedded in lignin matrix. The cellulose fibrils are combines along with the length of the fibre, which makes the tensile strength and flexural strength to be high. The nature of cellulose and crystallinity are proportional to the reinforcing efficiency of the natural fibre.

Natural fibres are consists of cellulose, hemicelluloses, lignin, pectin, and waxes. Cellulose consists of D-anhydroglucose ($C_6H_{11}O_5$) as repeating units, and at the C_1 and C_4 there is a linkages with 1, 4-b-D-glycosidic. Three hydroxyl groups exist at each of the repeating units which are the important matter need to consider in directing the crystalline packing and govern the physical properties of cellulose. [4]

According to M.J. John and S. Thomas (2007) [4], cellulose commonly exists in microcrystalline structure with region of high order and region of low order. Cellulose is also formed of slender rod like crystalline microfibrils. Cellulose can be easily hydrolyzed by acid to water-soluble sugars but it is resistant in alkali with 17.5 wt% to oxidizing agent. Hemicellulose is a combination of 5- and 6-carbon ring sugar with a group of polysaccharides. Hemicellulose naturally is a matrix for cellulose microfibrils and it is very hydrophilic, soluble in alkali and easily hydrolyzed in acids.

Lignin is consists of aliphatic and aromatic and it is complex hydrocarbon polymer. Lignin is not soluble in most of the solvent and it is exhibiting a glass transition temperature of $90\,^{0}C$ and melting temperature of around $170\,^{0}C$ since it is consider to be thermoplastics polymer. Lignin is soluble in hot alkali, readily oxidized, and easily condensable with phenol but lignin cannot be hydrolyzed by acids. Pectins (heteropolysaccarides) gives plants flexibility and wakes consists of different types of alcohols. [4]

Natural fibres or biofibres can be considered as natural composite with empty or hollow cellulose fibrils embedded with lignin and hemicellulose acting as matrix. A cellulose-hemicellulose combination is formed where by the hemicellulose act as cementing matrix between the cellulose microfibrils. Where less the lignin network act as a coupling agent and increase the stiffness of the cellulose–hemicellulose composite. The properties of the fibres are determined by the microfibrils angle, cell dimension, defects, and composition of the fibres. With the increasing in cellulose content, the

Young's modulus and tensile strength of the fibre increased as well. Some of the important natural fibres are listed in Appendix A. [4]

According to S. Biswas *et. al* (2006) [5], natural fibres such as sisal and banana fibres are cellulose rich (65%) and show tensile strength, modulus and failure strain comparable with other cellulose rich fibres such as jute and flax. There is also lignin rich (> 40%) coir fibre but it is relatively weak and posses high failure strain. Cellulosic fibres are obtained from different parts of the plant, for example jute and ramie are obtain from stem while sisal, banana and pineapple from the leaf.

According to recent research in India natural fibres can very well be used as reinforcement in polymer composite replacing synthetic fibre such as glass. So far the maximum tensile strength, impact and flexural strength for natural fibre reinforced plastics (NFRP) are 104.0 MN/m^2 (jute- epoxy), 22.0 MN/m^2 (jute- polyester) and 64.0 MN/m^2 (banana- polyester) respectively. Table 2.1 show the properties of some selected natural fibres compare with E-glass fibre. [5]

Rozman *et al*.(2001)[6] did a research on , the mechanical properties of polypropylene empty fruit bunch (EFB) composites and found that EFB has increased the tensile modulus, but decreased the tensile strength and impact strength of the composites. Abdul Khalil *et al*.(2001)[7] stated that modified EFB has improved the mechanical properties and water resistance of the polyester EFB composites. In recent research, EFB