Faculty of Engineering

PHYSICO-MECHANICAL PROPERTIES OF POLYETHYLENE REINFORCED WITH OIL PALM FIBER COMPOSITES

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This project report, which entitled "**Physico-Mechanical Properties of Polyethylene Reinforced with Oil Palm Fiber Composites**", was prepared by **Abdul Azim Bin Hamdan** as a partial fulfillment for the Bachelor's Degree of Engineering with Honours (Mechanical and Manufacturing Engineering) is hereby read and approved by:

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Physico-Mechanical Properties of Polyethylene Reinforced with Oil Palm Fiber Composites

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Dedicated to my beloved family and friends

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ABSTRAK

Sifat-sifat fizik dan mekanik komposit polietilena (PE) ditetulang dengan gentian tandan kosong buah sawit (OPEFB) dengan berlainan pertambahan berat (10, 15, 20, 25 dan 30 brt %) telah diselidik. Dua jenis rawatan kimia seperti agen oksida natrium metaperoksida dan agen gandingan urea telah diguna untuk memperbaiki sifat-sifat pada komposit. Fotograf kemikroskopan electron imbasan (SEM) pada ciri permukaan dan bahagian patah telah diambil untuk dikaji antara muka rekatan gentian/matriks. Pengurangan penggumpalan gentian dan antara muka diperbaiki melalui permerhatian dengan teliti menggunakan SEM dalam hal komposit PE ditetulang dengan gentian OPEFB terawat and keserasian diperbaiki dalam hal urea rawatan PE ditelulang dengan gentian OPEFB terawat. Modulus tegangan dan modulus lenturan bertambah dengan pertambahan berat gentian.Walaubagaimanapun, kekuatan lenturan didapati menurun setelah melewati 15% pertambahan berat gentian dan kekuatan tegangan menurun dengan pertambahan berat gentian. Kesan pada penyerapan air keatas komposit juga telah diperhati dan didapati bahawa komposit PE ditelulang dengan bergentian OPEFB terawat adalah kurang penyerapan air berbanding dengan komposit PE ditelulang dengan gentian OPEFB tidak dirawat dan urea rawatan PE ditelulang dengan gentian OPEFB terawat. Pada keseluruhannya, komposit PE ditelulang dengan gentian OPEFB yang telah dirawat secara kimia menunjukkan gentian/matriks saling tindak yang lebih baik seperti yang diperhati daripada penyerakan gentian di dalam sistem matriks. Dibandingkan dengan komposit PE ditelulang dengan gentian OPEFB tidak dirawat, kesemua komposit gentian OPEFB yang telah dirawat mempunyai kecenderungan yang sama untuk meningkat sifat-sifat mekanik pada komposit.

ABSTRACT

The physical and mechanical properties of polyethylene (PE) matrix reinforced with oil palm empty fruit bunch (OPEFB) fiber composites with different by weight loading (10, 15, 20, 25, and 30 wt%) have been studied. Two different types of chemical treatments such as oxidizing agent sodium metaperiodate and coupling agent urea has been used to improve the properties of the composites. Scanning electron micrographs photographs of the fractured and surfaces characteristics were taken to study the fiber/matrix interface adhesion. Reduced fiber agglomeration and improved interfacial was observed under scanning electron microscope in the case of PE reinforced with treated OPEFB fiber and improved the compatibility in the case of urea treated PE reinforced with treated OPEFB fiber composites. Tensile modulus and flexural modulus significantly increased with an increase in fiber loading. However, flexural strength is found decreased beyond 15% by weight fiber loading and tensile strength significantly decreased with an increase in fiber loading. Effect of water absorption on the composites was also observed and it was found that PE reinforced with treated OPEFB fiber composites are less absorbed by water compared with PE reinforced with untreated OPEFB fiber and urea treated PE reinforced with treated OPEFB fibers composites. Overall, chemically treated PE reinforced with OPEFB fiber composites showed better fiber/matrix interactions as observed from the good dispersion of fibers in the matrix system. Compared to the PE reinforced with untreated OPEFB fiber composites, all treated OPEFB fiber reinforced composites had same tendency to slightly increase the mechanical properties of composites.

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LIST OF ABBREVIATIONS

%	-	Percent
-OH	-	Hydroxyl
°C	-	Degree Celsius
°F	-	Degree Fahrenheit
σ_{fM}	-	Flexural strength
σ_{UT}	-	Tensile strength
A_T	-	Cross sectional area
AD	-	Anno Domini
ASTM	-	American standard test method
b	-	Width
BC	-	Before Christ
CCM	-	Carbon-carbon composite
C-glass	-	Corrosion-Resistant Glass
CMC	-	Ceramic matrix composite
CO_2	-	Carbon dioxide
$CO(NH_2)_2$	-	Urea
Co-polymer	-	Joint Polymer
CPE	-	Chlorinated polyethylene
d	-	Thickness
E_B	-	Modulus of elasticity
E-glass	-	Electrical glass
EFB	-	Empty fruit bunch

GPa	-	GigaPascal
H_2SO_4	-	Sulfuric Acid
HCOOH	-	Formic acid
HDPE	-	High density polyethylene
LLDPE	-	Linear Low density polyethylene
L	-	Support span
LDPE	-	Low density polyethylene
m	-	Slope of tangent
mm	-	Millimeter
MMC	-	Metal matrix composite
MPa	-	MegaPascal
$NaIO_4$	-	Sodium MetaPeriodate
NFRC	-	Natural fiber reinforced composites
OPEFB	-	Oil palm empty fruit bunch
PE	-	Polyethylene
PMC	-	Polymer matrix composite
PP	-	Polypropylene
PS	-	Normal polystrene
PVC	-	Poly (Vinyl chloride)
P	-	Maximum load
pH	-	Potenz Hydrogen
SEM	-	Scanning Electron Microscope
S-glass	-	High-strength glass
W	-	Breaking load
Wt	-	Weight

CHAPTER ONE

INTRODUCTION

1.1 Introduction to natural fiber reinforced composites

Natural fiber reinforced composites (NFRC) are finding much interest as a substitute for glass or carbon reinforced polymer composites [1]. Natural fibers, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. There are quite a few in favor of natural fibers if compared with other synthetic fibers, glass or carbon fibers. They are environmentally and economically friendly because they are fully biodegradable, abundantly available, renewable, cheap and low density.

When natural fiber-reinforced plastics are subjected to combustion process or landfill at the end of their life cycle, the release some amount of CO_2 which is neutral with respect to the assimilated amount during their growth [2]. The abrasive nature of fiber is much lower which leads to advantages in regard to technical process and recycling process of the composite materials in general. Natural fiber-reinforced plastics, using biodegradable polymers as matrices, are the most environmental friendly materials, which can be decomposed at the end of their life cycle. Natural fiber composites are used in place of glass mostly in non-structural applications. A number of automotive components previously made with glass fiber composites are now being manufactured using environmentally friendly composites [3].

Since Malaysia is one of the leading producers and exporters of palm oil, it generates large amounts of oil palm empty fruit bunch (OPEFB) waste biomass during palm oil extraction process in various palm oil mills. In Malaysia alone large amount of oil palm biomass are generated by the palm oil industry, for example 5000 million tones of felled trunk in 2000 [4], 36 millions tones per year of fronds from pruning and replanting [5] and 5.2 millions tones per annum of empty-fruit bunches (EFB) in 2002 [6]. In the oil extraction process the fruits or nuts are first stripped from fruit bunches, leaving behind the empty-fruit bunches as waste. The abundance of OPEFB has created an important environmental issue such as fouling and attraction of pests. However from this waste, valuable fiber can be obtained for manufacturing board and paper. Until now, OPEFB fibers have not yet reached its full potential in manufacturing industries and it is still quite new before it can be implemented in wider scale. This is because the physical and chemical nature of the fibrous strands prepared from OPEFB has not yet been investigated in detail.

1.2 Problem statement

Although natural fibers and their composites are environmental friendly and renewable (unlike traditional sources of energy, i.e., coal, oil and gas), these have several disadvantages. They have poor wetability, incompatibility with some polymeric matrices and high moisture absorption [7]. Composite materials made with the use of unmodified plant fibers frequently exhibit unsatisfactory mechanical properties. To overcome this, in many cases, a surface treatment or compatibilizing agents need to be used prior to composite fabrication. The properties can be improved both by physical treatments (cold plasma treatment, corona treatment) and chemical treatments (maleic anhydride organosilanes, isocyanates, sodium hydroxide permanganate and peroxide) [8]. Mechanical properties [9] of natural fibers are much lower than those of glass fibers but their specific properties, especially stiffness, are comparable to the glass fibers.

1.3 Introduction to the project

This project is only about finding the physical and mechanical properties of thermoplastic polyethylene reinforced by OPEFB fiber. This project focuses on finding the tensile strength and tensile modulus from the tensile test experiment. From the three point flexural test, the flexural strength and modulus of elasticity are determined. Next stage is the water absorption test of the composite, where the water absorption of the composite is measured to find the increase in weight percentage during immersion. The physical properties are determined by using the scanning electron microscope (SEM) where the fracture part of the tensile test specimen is examined.

The project begins by studying the oil palm empty fruit bunch (OPEFB) fiber and the polyethylene matrix. The process of the producing the sample the specimen is focused. Producing composite is the hardest task because only the finest specimen will produce accurate results. After studying the OPEFB fiber characteristics and properties, the finest OPEFB fiber can be produced. The characteristic of thermoplastic polyethylene is also very important and must be studied because it will be essential during producing the composite process. Next is to select the oxidizing agent for the chemical treatment of the OPEFB fiber and coupling agent for the physical treatment of the treated fiber composite.

1.4 Aim and purpose

The aim of this project is to find out the physical and mechanical properties of three types of composites. The first type is thermoplastic polyethylene reinforced by raw oil palm empty fruit bunch (OPEFB) fiber composite. The second type is thermoplastic polyethylene reinforced by pre-treated OPEFB fiber composite. Final one is post-treated of thermoplastic polyethylene reinforced by pre-treated OPEFB fiber composite. Each of these composites is compared using their properties obtained from the experiment that have been conducted. Mechanical properties are determined by tensile test, flexural three point bending test and water absorption test, while the physical properties are determined by scanning electron microscopic test. Experiments are conducted on these three composite specimens. When all of the experiments are being conducted, the results are used to compare them to determine their properties.

1.5 Scope of the project

In the beginning of this project, thorough study about the composite, natural fiber composite, thermoplastic matrix, thermoplastic polyethylene matrix and OPEFB fiber is conducted. All this information must be gathered because this project is about thermoplastic matrix reinforced by natural fiber. All the information gathered are combined and used for writing the literature review described in chapter 2.

The process of producing the composite need to undergo a few stages before it can be prepared for testing. The fiber loading is varied at 10, 15, 20, 25 and 30 weight percentage during composite manufacturing. This project is only concentrating on the mechanical and physical properties of the composite. To be more specific, on mechanical properties part, the tensile strength and Young's modulus from tensile test, flexural strength and modulus of elasticity from three point bending flexural test and increase in weight percentage during immersion from water absorption test are obtained. The physical properties are determined by using the scanning electron microscope (SEM) the fracture part of the tensile test specimen is examined.

This report contains 5 chapters which are introduction, literature review, methodology, results, analysis and discussions and conclusions and recommendations. For introduction, it concerns more on the purpose, aim and problem that need to be overcome in this project. Chapter 2 concentrates on information from internet, thesis, journal and books that relate to the project. Chapters 3 explain procedure that are needed to be carry out to overcome problem and reach the project aim. Chapter 4 is focusing on results that are supported with data, plots and graphs comprehensive conclusions that is translate from the result. This result is derived from predefined methodologies and parameters. Finally chapter 5 is highlighting the overall conclusions of the project discussing the objectives and aim and recommendations on improving the project due to limitations of the project.