INVESTIGATION ON TENSILE AND HARDNESS PROPERTIES OF NOVEL HYBRID OIL PALM EMPTY FRUIT BUNCH/ KENAF REINFORCED HIGH DENSITY POLYETHYLENE COMPOSITE FOR AUTOMOTIVE APPLICATION

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled "Investigation On Tensile And Hardness Properties Of Novel Hybrid Oil Palm Empty Fruit Bunch/ Kenaf Reinforced High Density Polyethylene Composite For Automotive Application" is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

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 (Automotive).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

Natural fibre composites (NFC) is currently being applied as substitute material for synthetic composites especially in automotive application. Oil palm empty fruit bunch (OPEFB) fibre is one of the potential source of reinforcement material for NFC, which offers low raw material cost for automotive application due to its abundance as major waste materials in Malaysia oil palm industry. However, OPEFB application is still limited due to the low structural performance of the fibres as compared to other type of natural fibre. Hybridization of OPEFB with other natural fibres is one of the alternative to compensate the drawback of OPEFB structural performance, while retaining balance to the overall material cost. In this research, a novel hybrid OPEFB and kenaf reinforced high density polyethylene (HDPE) composites was develop for automotive application. The aim of this research was to investigate the effect of tensile and hardness properties of novel hybrid OPEFB/kenaf reinforced HDPE composite at varying OPEFB fibre loadings. All samples were prepared at fix fibre to matrix ratio of 40:60 wt%. Meanwhile, the OPEFB/kenaf fibre loadings ratio were varied 40/0, 10/30, 20/20, 10/30 and 0/40 wt%. The fibres were first crushed and sieved to size between 1 t0 5 mm. Hybrid short fibers were later mixed with HDPE using compounding and formed into thin plates using hot compression moulding process. Finally, the samples were cut to size and tested in accordance to the ASTM D2240 for the hardness test. The Shore-D hardness values of the samples were later converted into tensile modulus using theoretical method. Based on the result of hardness and approximate tensile modulus, the hybrid composite samples of 30 wt% Kenaf + 10wt% OPEFB fibre loadings showed the highest hardness property at 73.77 HD or 32.79 N, with approximate tensile modulus of 335.24 MPa. The 30/10 hybrid formulation was able to increase approximately 1.65 times tensile modulus as compared to pure OPEFB reinforced HDPE composites. The findings revealed potential success of hybridizing OPEFB with kenaf to improve the structural performance of OPEFB thermoplastic composites, especially for automotive structural application.

ABSTRAK

Dalam zaman sekarang, komposit yang diperbuat daripada gentian semula jadi (NFC) telah dijadikan bahan penggantian kepada sintetik komposit. Gentian tandan kosong kelapa sawit (OPEFB) merupakan salah satu sumber yang berpontesi untuk memperkukuhkan NFC. OPEFB dapat dijadikan bahan mentah dalam aplikasi automotif dan diperoleh dengan harga yang rendah kerana ia merupakan produk sisa utama daripada industri kelapa sawit dan kuantitinya banyak dihasilkan. Walaupun begitu, aplikasi OPEFB masih terhad kerana prestasi strukturnya yang rendah berbanding dengan gentian semula jadi yang lain. Hibridisasi OPEFB dengan gentian semula jadi yang lain merupakan salah satu cara alternatif untuk mengimbangi kelemahan OPEFB dalam prestasi strukturnya, dengan cara ini keseimbangan kos bahan mentah dapat dikekalkan. Dalam kajian ini, NFC yang diperbuat daripada hibrid OPEFB dan Kenaf diperkukuh dengan polipropena ketumpatan tinggi (HDPE) telah dikaji untuk aplikasi automotif. Tujuan kaji ini adalah untuk mengaji kesan sifat kekenyalan dan kekerasan NFC yang diperbuat daripada hibrid OPEFB dan Kenaf diperkukuh dengan HDPE dengan penukaran pemuatan gentian OPEFB. Semua sampel telah disediakan dengan mengikut nisbah gentian dan matriks yang ditetapkan iaitu 40:60 wt%. Sementara itu, nisbah pemuatan gentian OPEFB/Kenaf diperubahkan dengan 40/0, 10/30, 20/20, 10/30 and 0/40 wt%. Pertama, gentian telah dihancurkan dan dilapis untuk medapatkan saiz gentian yang di antara 1mm dan 5mm. Hibrid gentian pendek akan dicampurkan dengan HDPE dan campuran ini menggunakan cara pengkompaunan. Selepas itu, ia dijadikan plat nipis dengan proses acuan mampatan panas. Akhirnya, sampel itu telah dipotong kepada saiz dan diuji megikut ASTM 2240 yang merupakan standard untuk uji kekerasan. Nilai kekerasan sampel yang didapatkan dengan penggunaan Shore-D hardness telah ditukarkan kepada modulus tegangan dengan menggunakan cara teori. Berdasarkan keputusan kekerasan dan anggaran modulus kekenyalan, sampel komposit hibrid yang mengandungi 30 wt% Kenaf + 10wt% OPEFB pemuatan gentian menunjukkan sifat kekerasan tertinggi iaitu 73.77 HD atau 32.79 N dan anggaran modulus kekenyalan ialah 335.24 MPa. Komposit yang diperbuatkan daripada formlasi 30/10 dapat meningkatkan prestasi modulus kekenyalan kira-kira 1.65 kali ganda berbanding dengan komposit OPEFB tulen diperkukuh dengan HDPE. Penemuan ini mendedahkan potensi kejayaan hibridasi OPEFB dan Kenaf dapat meningkatkan prestasi stuktur OPEFB dalam komposit termoplastik, terutamanya dalam aplikasi automotif struktur.

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LIST OF ABBREVIATIONS

HDPE	High density polyethylene
OPEFB	Oil palm fruit bunch
ASTM	American Society for Testing and Materials
std dev	Standard deviation

LIST OF SYMBOLS

wt%	=	Weight percentage
S_D	=	Hardness reading of Shore D durometer
E	=	Tensile modulus

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, the number of vehicle in the whole world is growing dramatically. On the other hand, the current trend has shown that life span of the vehicle is shortening and it results that the number of the End-of-life vehicle (ELV) is also increasing. ELV stands for the discarded vehicles or the vehicles that is going to be discarded. The vehicle sector has contributed about 5% of the world's industrial waste and the discarded vehicles give a big impact to the environment as they contain of mercury, cadmium, hexavalent chromium, anti-freeze, brake fluid and oils which may pollute the environment if they are not handled well. Currently, the recyclable part for a vehicle is the metal part such as steel and aluminum. Life cycle assessment (LCA) is a method that is used to evaluate the environmental sustainability of a product. Alves and his team had used the LCA to show the possibility and advantages for applying the natural fibres in the automotive sectors [1].

Oil palm industry is one of the main agroindustry in Malaysia which is also the main income of the country. In 2000, Malaysia was once the largest producer and exporter of oil palm in this world, which Malaysia produced 10.8 million tonnes of oil palm annually and this amount was around 50% of the world palm oil production. In 2008, Malaysia's production had grown up to 17.7 million tonnes and 4,500,000 hectares of land had been used for planting the oil palm tree. It is expected that in between 2016 and 2020, the production of oil palm will be 15.4 million tonnes annually. The industry has grown big and the impact on the environment is also growing. Hence, the Roundtable for Sustainable Palm Oil (RSPO) which is a NGO has been formed, and it is supported by the government and Malaysia Palm Oil Council (MPOC). This organization's aim is developing a sustainable oil palm industry. In processing the oil palm, it will produce large amount of solid waste and liquid waste such as empty fruit bunches (EFB), mesocarp fruit fibers (MF), palm kernel shells (PKS) and palm oil mill effluent (POME). The waste disposal of the oil palm has become a critical issue and developing a sustainable method is necessary and encouraged [2].

There are two categories of fibres which are the synthetic fibres and the natural fibres. Natural fibres are widely used in this world since thousand years ago such as cotton. Natural fibres can be obtained from the plant, animal and minerals each of them has different properties. For the fibres from plant, the fibres can be obtained from the leaf, seed, bast, core and others. The natural fibres is environmental friendly as it is biodegradable and renewable. Comparing to the synthetic fibres, the natural fibres possess the advantages such as recyclable, nonabrasive, acceptable specific strength and modulus, low density, good acoustic property, low cost, and easily available. There are also weaknesses on the natural fibres. They are facing the problem of the high tendency to absorb the moisture, poor wettability, low adhesion with the synthetic matrix and poor thermal stability during processing [3].

Oil palm empty fruit bunch (OPEFB) fibres is the natural fibre that is obtained from the waste product of the oil palm industry. The source of this fibre is abundance and it is recyclable and low cost. Same as other natural fibres' limitation, the OPEFB has low thermal stability during process and it processing temperature is limited at about 200°c as it may degrade or have volatile emission during process and affect the properties of the composite. From the investigation of Rozman and his team, they mixed the OPEFB and the high density polyethylene (HDPE) and the result showed that increase of the percentage of OPEFB in the composite polymer will decrease the flexural, tensile, and impact strengths [4].

Kenaf fibre is a natural fibre which can be easily found in Malaysia. The species of Hibiscus cannabinus is the species of Kenaf. Kenaf is a plant with fibrous stalk hence it is resistant to damage of insect, only few or no pesticide are needed to be used on it [5]. It is economically cheaper if compared with other natural fibres that can be found in Malaysia. It is widely used in making the composite polymer as the reinforce fibre. Generally, a composite polymer that contains of Kenaf fibre will show a good result in tensile and flexural testing [6].

There are two types of matrixes that are used to form composite polymer which are thermoplastic and thermoset. Thermoplastic matrixes that are commonly used are polyethylene (PE), polypropylene (PP), polystyrene (PS), and PVC (polyvinyl chloride), and thermoset matrixes that are commonly used are epoxy resin, polyester, phenol formaldehyde, and vinyl esters. Both matrixes are not fully biodegradable. Strength and stiffness of the composite polymer can be varied by controlling the composition of the fibre in the polymer. By increasing the volume of fibre in the polymer, the thermal conductivity and thermal diffusivity will decrease but it doesn’t show significant effect in the temperature range of 170°c to 200°c [7]. Polyethylene is always chosen as the matrix in forming bio composite polymer as it has high availability, low melting point, low cost and recyclable [4].

1.2 Problem Statement

The automotive market is growing larger and the number of waste material that is caused by automotive is also increasing. The metal parts of the automotive can be recycled but most the plastic used in it cannot be recycled. The use of recyclable or biodegradable plastic can help to increase the recyclability end-of-life performance of vehicles. In another scenario, Malaysia is one of the biggest producers of oil palm in the world. Large oil palm industry produces large amount of waste, such as empty fruit bunch. The oil palm empty fruit bunch (OPEFB) can be processed into natural fibre, which can later be utilized to produce natural fiber composites (NFC). NFC is among the growing source of materials applied in the automotive sector. The feasibility of applying NFC for automotive application depends on many factors, such as type of fibre, processing method, reinforced matrix, weight percentage of fibre and others. Hybridization is one of the technique used to produce NFC, which able to offer a balance between cost and performance between the mix fibers. Up to date, there is very limited research on the characterization of hybrid OPEFB with other type of natural fibers, especially kenaf fiber. More limited source of information is also presence with regards to the performance of OPEFB composites produced using high density polyethylene (HDPE) thermoplastic matrix. In this research, the study on mechanical properties, namely hardness and tensile modulus of novel hybrid OPEFB/kenaf reinforced HDPE composites for automotive application were conducted. Varying OPEFB to kenaf fiber ratio was used to formulate the samples. All fibers were crushed and sieved to short fiber form, with size ranging between 1 mm to 5 mm. Thermoplastic compounding process and hot compression moulding process were also utilized to prepare the samples. The hardness testing based on ASTM D2240 was used to determine the Shore hardness value of the samples, while theoretical method was applied to convert the hardness value to equivalent tensile modulus properties.

1.3 Objectives

The objectives of this project are as follows:

i. To find the hardness of hybrid oil palm empty fruit bunch/kenaf reinforced HDPE with varying weight ratio of oil palm empty fruit bunch, kenaf and HDPE.

ii. To find the approximate tensile modulus of hybrid oil palm empty fruit bunch/kenaf reinforced HDPE with varying weight ratio of oil palm empty fruit bunch, kenaf and HDPE.

1.4 Scope of Project

The scopes of this project are:

1. To find the hardness of hybrid oil palm empty fruit bunch/kenaf reinforced HDPE
2. To find the approximate tensile modulus of hybrid oil palm empty fruit bunch/kenaf reinforced HDPE
3. The formulation of bio composite formula is determined by weight percentage. The weight ratio of natural fibre to HDPE will remain at 4:6.
4. Report writing.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural Fibre

Fibre is a material that has continuity of filament which is looked like a thread. Natural fibre is an environment friendly item, basically it can be divided into three categories which are animal, plant and mineral. Animal fibre is the fibre that is obtained from animal such as silk, sheep's wool and feather. The mineral fibre is the fibre that is formed from the mineral naturally or the fibre obtained from mineral but has been slightly modified such as ceramic and metal fibre. Plant fibre is the fibre that obtained from parts of plant, basically it is made up from cellulose. For this fibre, it can be re-categorised into five groups which are seed fibre, skin fibre, leaf fibre, fruit fibre and stalk fibre [8].

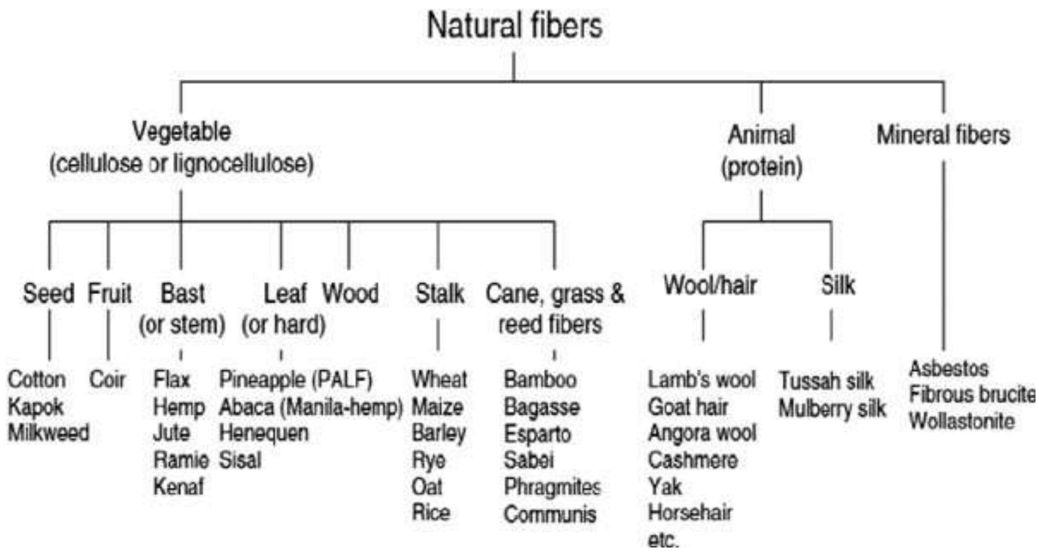

Figure 2-1: Categories of natural fibre [8]

The natural fibres is biodegradable and renewable hence it will not harm the environment and the source will not deplete. Besides, the natural fibres has also reasonable specific strength and modulus and low cost which can provide a product with good strength and low weight. Lastly, they are inexpensive and easily be obtained. However, the natural fibres tend to absorb moisture and provide a low adhesion force while processing with synthetic matrix. During processing, the natural fibres also show a poor thermal stability [3].

The natural fibres' properties depend on the chemical composition and the architecture. However, the natural fibres that contain of more cellulose and is aligned with the cellulose microfibrils will show a better performance. Previously, the asbestos group, which is a mineral natural fibre, was used extensively in making composite but due to the health issues such as carcinogenic, it is prohibited by many countries [9].

2.1.1 Oil Palm Empty Fruit Bunch

OPEFB is the waste product that is produced after the fresh oil palm fruit bunch is extracted for palm oil. Malaysia is one of the main exporter for palm oil in this world. The oil palm industry has produced huge amount of biomass residues every year. OPEFB is one of the main biomass residues, it is around 15.8 Million ton each year [10]. The composition of holocellulose in a OPEFB is 65 percent and the lignin content is 25 percent. The utilization of OPEFB will reduce the environmental issue caused by by-product of the oil palm industry [11]. With the amount of OPEFB generated each year, the source for producing the product with OPEFB base will be sustained [10].

2.1.2 Kenaf

Kenaf is a plant that under genus Hibiscus family and it is a dicotyledons plant. It is originated from ancient Africa. The growth rate of the Kenaf plant is fast and the yield in each year is 600-10000 kg of dry fibre from one acre of field. The survival rate of the Kenaf plant is high as it can adapt to across the broad of the climate condition. Low amount of water and fertilizers are needed to sustain the Kenaf plant. It is also a tough plant which can withstand the insect harm and it can grow well in various type of soil. Kenaf's bast can produce long fibre and the core can extract the short fibre [12]. In Malaysia, Kenaf fibre is relatively accessible and the cost will be lower if compared with other natural fibres. It is highly used in the bio-composite sector [6].

Figure 2-2: The dense kenaf plantation in Malaysia [6]

Raw Kenaf fibre is lignocellulosic fibre when it is extracted from the outer bark. The cellulose content of the Kenaf fibre is roughly 0.7 percent and the lignin and pectin consist of 21.6 percent. At bottom of the stalk, the length of fibre is commonly short but it grows