A STUDY ON IMPACT PROPERTIES OF HYBRID OIL PALM EMPTY FRUIT BUNCH/ KENAF REINFORCED HIGH DENSITY POLYETHYLENE COMPOSITES FOR AUTOMOTIVE APPLICATION

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DECLARATION

I Muhamad Fahmi bin Md Noor declares that this project report entitled "A Study on Impact Properties of Hybrid Oil Palm Empty Fruit Bunch/ Kenaf Reinforced High Density Polyethylene Composites for Automotive Application", under the guidance of Dr. Muhd Ridzuan bin Mansor, is my original work except references material.

Signature : _____

Name : Muhamad Fahmi bin Md Noor

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 : _____

Supervisors Name : Dr. Muhd Ridzuan bin Mansor

Date : _____

DEDICATION

I dedicated my study to my beloved mother and father who always give motivation and encouragement to finish my study until the ends. I also want to thanks to my brother and sister the person never left my side cheer and raise my spirit to work harder to complete the study. Not forgotten to my friends who always supported me throughout the process. Last but not least, I will always appreciated all they have done especially to Dr. Ridzuan the person always guide me to finish the work, Mr. Taufiq who assisted me in the laboratory and sharing knowledge. I want to give special thanks again to all person who helps in this works and supported me to the ends.

ABSTRACT

Nowadays, the natural fibre reinforced thermoplastic composites have attracted attention many researcher and industrial player as potential renewable and biodegradable source of raw material especially for automotive application. Among the potential candidate material for natural fiber composites (NFC) application is oil palm empty fruit bunch (OPEFB) fibres, which is a waste product in the oil palm industry. Hence, OPEFB offer very low cost with high availability, thus making it very suitable for NFC production. In this study, a novel hybrid NFC utilizing OPEFB and kenaf fibre reinforced thermoplastic high density polyethylene (HDPE) composites (OPEFB/Kenaf/HDPE) is developed. The purpose was to characterize the impact properties of hybrid OPEFB/Kenaf/HDPE composites at varying OPEFB fiber loadings. In addition, the effect of moisture to the impact properties of the hybrid OPEFB/Kenaf/HDPE composites was also investigated. The OPEFB fibre loadings were varied from 0, 10, 20, 30, and 40 wt%, with fixed HDPE contents of 60 wt%. the fibers were first crushed and sieved to size between 1 to 5 mm. Hybrid fibers were later mixed with HDPE using compounding and formed into thin plates using hot compression molding process. Finally the sample is cut to size and characterize in accordance to the ASTM D256 for the impact test using Izod impact testing apparatus. For the moisture absorption study, all samples were soaked for 29 days in distilled water prior to the impact testing. Overall results from the tests showed that hybrid composites at 30 wt% of OPEFB have the highest impact strength compared to other hybrid formulation. The hybrid formulation was able to increase up to twice the impact strength of the 100% OPEFB/HDPE composites. Furthermore, the effects of water absorption were also found to increase the impact strength for all formulation as 12.8% in average. The findings showed the potential of utilizing hybrid technique to improve the impact performance of OPEFB/HDPE composites especially to cater higher impact load bearing automotive applications.

ABSTRAK

Pada masa kini, serat semulajadi komposit bertetulang termoplastik telah menarik perhatian ramai penyelidik dan juga industri sebagai sumber tenaga mentah yang boleh diperbaharui dan biodegradable terutamanya untuk aplikasi automotif. Antara bahan yang potensial untuk komposit serat semulajadi (NFC) ialah serat buah kelapa sawit (OPEFB), yang merupakan produk sisa dalam industri kelapa sawit. Oleh itu, OPEFB menawarkan kos yang rendah, mudah didapati, dan menjadikannya sesuai untuk pengeluaran NFC. Dalam kajian ini, NFC hibrid baru yang menggunakan OPEFB dan serat kenaf diperkuat komposit polietilena berketumpatan tinggi termoplastik (OPEFB/Kenaf/HDPE) dibuat. Tujuannya adalah untuk mencirikan sifat-sifat hentaman komposit OPEFB/Kenaf/HDPE hibrid pada pelbagai beban serat OPEFB. Di samping itu, kesan kelembapan kepada sifat hentaman komposit OPEFB/Kenaf/HDPE hibrid juga disiasat. Beban serat OPEFB berbeza berat dari 0, 10, 20, 30, dan 40%, dengan kandungan HDPE tetap sebanyak 60%. Serat dihancurkan dan disaring pada saiz antara 1 hingga 5 mm. Serat hibrid kemudian dicampur dengan HDPE menggunakan pengkompaunan dan dibentuk menjadi plat nipis menggunakan proses pengacuan mampatan panas. Akhirnya sampel dipotong kepada saiz mengikut ASTM D256 untuk ujian hentaman menggunakan alat ujian hentaman Izod. Untuk kajian penyerapan kelembapan, semua sampel direndam selama 29 hari dalam air suling sebelum ujian hentaman. Keputusan keseluruhan dari ujian menunjukkan bahawa komposit hibrid pada berat 30% OPEFB mempunyai kekuatan hentaman tertinggi berbanding dengan formula hibrid yang lain. Rumusan hibrid mampu meningkatkan hingga dua kali ganda kekuatan hentaman komposit OPEFB/HDPE sebanyak 100%. Selain itu, kesan penyerapan air juga didapati meningkatkan kekuatan hentaman untuk semua perumusan sebanyak purata 12.8%. Penemuan menunjukkan potensi menggunakan teknik hibrid untuk meningkatkan prestasi kekuatan hentaman komposit OPEFB/HDPE terutamanya untuk menampung kekuatan hentaman yang lebih tinggi pada aplikasi automotif.

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First of all, I would like to take this opportunity to express gratitude to my supervisor Dr. Muhd Ridzuan bin Mansor from the Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) been able to supervised, give support and encouragement towards the completion of the final year project. I also want to thanks the technician of Faculty of Manufacturing Engineering laboratory who always support and give good cooperation to finish this project smoothly. Not forgotten to express my appreciation to technician of Faculty of Mechanical Engineering who always assist and sharing the knowledge to used equipment and tools. Last but not least, I want to express special thanks to my family especially to my parents, to my beloved siblings, and to my peer for their moral support in completing this degree.

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LIST OF ABBREVIATION

OPEFB	Oil Palm Empty Fruit Bunch
HDPE	High Density Polyethylene
PS	Polystyrene
PVC	Polyvinyl Chloride
PP	Polypropylene
PE	Polyethylene
CO_2	Carbon Oxide
HPT	High Process Temperature
LPT	Low Process Temperature
NaOH	Sodium Hydroxide
SEM	Scanning Electron Microscopy
Tp	Thermoplastic
Ts	Thermoset
(wt%)	Weight percentage
ρ	Density
V	Volume
m	Mass

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia is one the bigger producer of oil palm in the world. The huge production of oil palm is is worrying due to waste oil palm disposal problems. Therefore, there is need to reduce the waste and optimize the utilization of the oil palm product, by using the recycle method which can support the "waste to wealth" initiative, (Matovic, 2013).

Neutral fiber has three main different of classification which plant, animal and material and oil palm is one of natural fiber come from plant category. Each of categories has different properties and also widely used nowadays. Using of natural fiber is highly recommended because low cost, recyclability, and biodegradable advantages material but there must be the disadvantage and limit of use in natural fiber. Natural fiber is poor due to wettability and tendency of water absorption is high and also low thermal effective, (Yahaya et al., 2015).

The advantage of recyclability and biodegradability of neutral fiber, oil palm can be recycle and use to create new green biocomposite material by mixing neutral fiber with matrix to increase the properties of material. Base on the main issues of disposal problem of oil palm, it can turn it from waste to profit by using this method. This research only focusing on the mechanical and morphological properties of plant-based biocomposite, OPEFB/Kenaf reinforced high density polyethylene HDPE.

Kenaf is natural fiber and also widely used in producing composite material. Kenaf is one of world production material and cheaper material from other neutral fiber classification in Malaysia. From previous research, kenaf is used for reinforced matrix composite which shown good result properties from tensile and flexural testing (Saba et al., 2016).

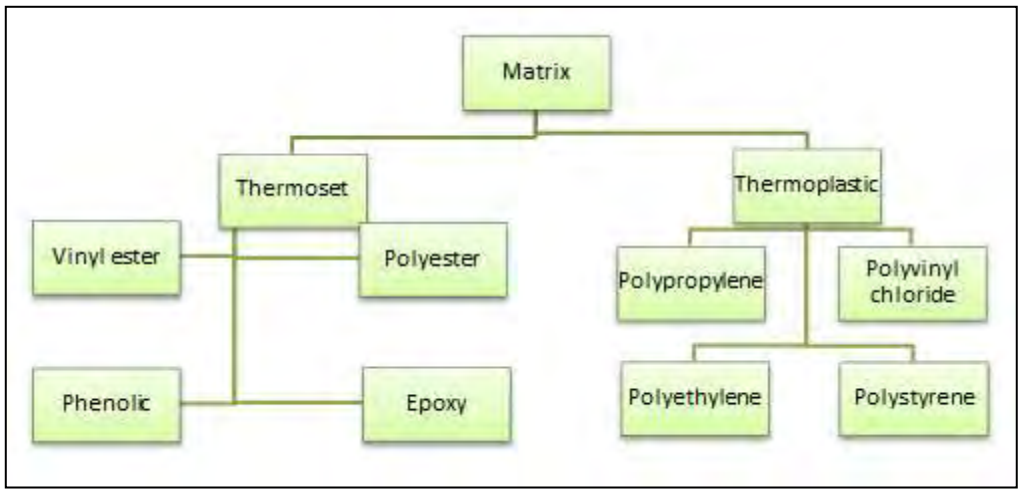

Figure 1.1 Classification of matrix

In this study will focus on thermoplastic instead of thermoset because of recyclability advantage of thermoplastic is more accurate type to create new green biocomposite material. Refer from previous studied report about polystyrene (PS) and polyvinyl chloride (PVC), there is not much data can get. Furthermore, between polypropylene (PP) and polyethylene (PE), PP contains carbon oxide, (CO_2) which in term of environmental of performance are lacking then PE. Therefore, PE is the best to use for creating new green biocomposite material. In mechanical properties PE, it has good deformation, fracture, thermal diffusivity and conductivity, and specific heat. In case to improve the toughness it can vary the volume of fiber. HDPE can be decrease in thermal conductivity and diffusivity by increase the volume of fiber material but the properties of HDPE remain same if heating the HDPE in range temperature of 170℃ to 200℃. In other hands, specific heat will increase gradually with the temperature, (Faruk et al., 2012).

1.2 Problem Statement

OPEFB composite is good in term of density but lack in mechanical properties. This problem can be solves by using hybrid composites material method to improve the OPEFB mechanical properties. In Malaysia have certain fiber readily available such as banana, pineapple, and kenaf. Between all the fibers producing in Malaysia, kenaf is the best composites material in term of strength. The problem is the performance of hybrid OPEFB/kenaf reinforced HDPE composite in impact mechanical properties still undefined.

1.3 Objective

The objectives of the project are as follows:

i. To determine the effect of varying fiber contents on the impact properties of hybrid oil palm empty fruit bunch/ kenaf reinforced high density polyethylene composites.

ii. To evaluate the effect of water absorption on the impact properties of hybrid oil palm empty fruit bunch/ kenaf reinforced high density polyethylene composites.

1.4 Scope of Study

The scope of work is:

i. To conduct the literature review.

ii. To conduct sample preparation of hybrid OPEFB/kenaf at varying OPEFB weight content ($wt\%$) using compression molding process.

iii. To test sample using Izod impact testing machine.

iv. To conduct surface morphology examination using scanning electron microscopy.

v. To perform data analysis.

vi. Report writing.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural fiber and classification

Commonly there are categorized natural fibers based on plant, animal and mineral. Based on plant fiber is containing cellulose as major structural. For mineral natural fibers basically exist within mineral group of asbestos. Nowadays, mineral natural fibers are avoided from used because of effect from health issues through breathing. Many countries around the world alert this issue and band it from used. Lastly the animal fiber original contain protein. (Pickering et al., 2016)

Cellulose can be divided into three categories. Each category depends on the plant extraction which from bast or stem fiber, leaf fiber or seed fiber. There are lots of type cellulose fibers reinforced with matrix to form new composite material. For example, kenaf, jute, and oil palm empty fruit bunch is commonly used in research study to form new composite material. (Jawaid & Abdul Khalil, 2011). Faruk et al., (2012) also stated that there are six types natural fibers basically. The classification as follows:

i. Bast fibers which is jute, hemp, flax, kenaf and ramie.
ii. Leaf fiber is sisal, abaca and pineapple.
iii. Seed fibers which are coir, kapok and cotton.
iv. A core fiber is hemp, kenaf and jute.
v. Grass fiber and reed fiber which is wheat, corn and rice.
vi. Other type's fiber is from wood and roots.

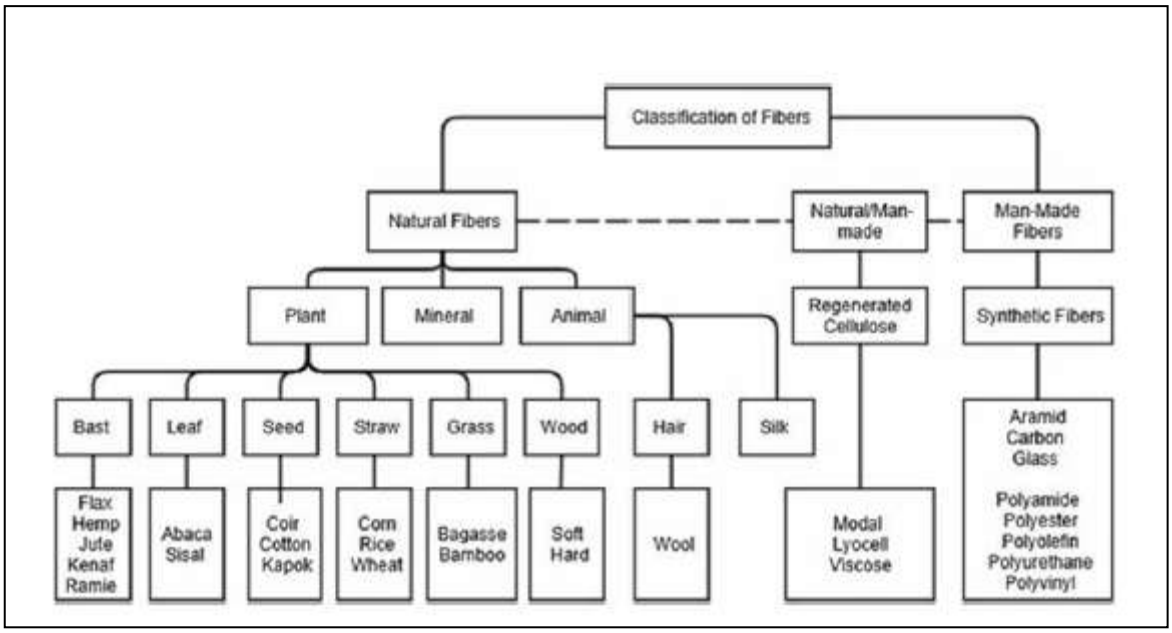

Figure 2.1 Schematic representation of fiber classification (Ramamoorthy et al., 2015)

There are a lot of advantages using natural fibers. It because natural fibers are low cost, and the material is availability. It also can be renewable, recyclable and biodegradable with low density and have good specific strength modulus. But improvement of natural fiber still limited in water absorption and low thermal stability (Yahaya et al., 2015). Based on Sanjay et al (2015) study, the natural fiber is different advantage between synthetic fibers. Natural fiber is having low density and also low cost then synthetic fibers. Furthermore, natural fiber can be recycle and renewable which synthetic cannot do both characteristics. Natural fibers also are biodegradable with no health risk when breathing. However, there are disadvantage of natural fibers due low water absorption, poor bonding with polymer, and low durability which bring to undesirable characteristic of composite in certain industrial usage. (Al-Oqla et al., 2015)

2.2 Kenaf fiber

Kenaf fiber is one of the natural fiber families. This fiber also widely used available and cheapest fiber. Kenaf can originally from plants genus Hisbiscus. The plant can be found in Africa and Asia in tropical and sub-tropical (Salleh et al., 2012). Within in three months, the growing of kenaf plant longer than 3 m with stem diameter range in 0.025m to 0.051m. Therefore, the kenaf plants is available as long fiber character (Mahjoub et al., 2014). Kenaf is is different in bast and core characteristic. For kenaf bast is contain 30% of total dry weight of stalk and kenaf core is contain 70% fibers. For core part consist low density which about 0.1g/cm^3. Additionally, kenaf stem can used for composite fiber and create products (Paridah et al, 2011).

Figure 2.2 Kenaf core and kenaf bast (Saba et al., 2015)

Among the natural fibers, kenaf is one of the the fiber in characteristic which have long fiber with small diameter. It also has good interfacial adhesion to polymer character (Yousif et al, 2012). Therefore, based on study Fauzani et al (2014), HDPE polymer are used to reinforced with kenaf fiber. The composites kenaf fiber/HDPE presented good tensile modulus outcome result at high process temperature HPT is better than at low process temperature LPT.

2.3 Oil Palm Empty Fruit Bunch (OPEFB)

OPEFB is obtained from the process of oil extraction from fruit bunch. The growth of oil palm plantation is creating the problem in vegetable waste and replanting operations. Malaysia have produced about 30 million tons of oil palm in recent past year study. Researcher stated this fiber will be give benefit to economic if utilization of the waste of OPEFB (Jawaid et al., 2010). Utilization of renewable resources is strategic to minimize the impacts of environment and give sustainable energy resources. In addition, it can solve the disposal problem and reduce the use of plastic in commercial applications (Razak & Kalam, 2012).

2.4 Matrices for biocomposites

Summerscales et al (2013) state that the mechanical performances depend on the load transfer and affect the bonding of chemical and physical properties between matrix and fiber. Therefore, to improve the performance of mechanical properties can be achieve by using polymers. Matrices can be classified into two classifications which are thermoset and thermoplastic. Each classification has different in mechanical properties. Based on Faruk et al (2014), to improve the performance of natural fiber need to do more research on varying fiber-matrix adhesion, process, manufacturing and treatment to natural fiber. Mostly, investigation focus on mechanical properties in tensile, flexural and impact test properties to analyze the weak spot of natural fiber reinforced matric composites.