UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY OF MECHANICAL PROPERTIES IN RELATION WITH MORPHOLOGICAL STRUCTURE OF PP/KENAF FIBER REINFORCED PLASTIC COMPOSITE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Materials Engineering) with Honours.

by

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FACULTY OF MANUFACTURING ENGINEERING

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Material Engineering) with Honours. The member of the supervisory committee is as follow:

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ABSTRACT

This research aims to study and analyze the effects of different fiber loading and coupling agent addition on the mechanical properties and its relationship to the micro structural behavior of the kenaf fiber reinforced polypropylene composites. The main raw materials used in this project are polypropylene (PP) resin as matrix materials and kenaf fiber as reinforcement materials for the composite fabrication. Typically, the observed size of kenaf fibers used in this study is around 513.39µm. The composite panels were fabricated by using an internal mixer and compression molding machine and were then cut into the specific dimension according to the specific ASTM standard of testing. The specimens primarily were tested for the Critical Properties Analysis - Tensile Test. The best compounding formulation of composite was found at the weight percentage (wt%) of 60wt% of PP matrix and 40wt% of the kenaf fibers. Further analyses for various mechanical properties of the composite were done accordingly to all composites formulation. The microstructures of tested specimens fracture surface were observed as to understand the fracture behavior, the fiber distribution and the surface morphology and its significant correlation to the mechanical properties studied. The results showed that the increasing of fiber loading had significantly increased the mechanical properties of the fabricated composite. The introduction of 3wt% of polypropylene-graft-maleic anhydride (MAPP) was done to the best formulated composites which indicate the improvement of the interfacial adhesion between the fiber-matrix interphase through the morphology observed and also improvement in the properties studied especially in water absorption behavior. Through the study, the enhancement of fabricated composite could be applied to the structural engineering applications through the advantage of the mechanical properties performance of tensile, flexural and impact properties.

ABSTRAK

Matlamat penulisan kertas kerja ini adalah untuk mengkaji dan menganalisis kesan penambahan gentian dan agen perangkai serta hubungan struktur mikro pada sifat mekanik komposit gentian kenaf yang diperkuatkan dengan polipropilena. Bahan utama yang digunakan di dalam kajian ini adalah resin polipropilena (PP) sebagai bahan matrik dan gentian kenaf sebagai bahan penenulangan komposit. Saiz gentian kenaf yang digunakan dalam kajian ini adalah dalam lingkungan 513.39µm. Kepingan komposit dibentuk dengan menggunakan mesin pencampuran dalaman serta mesin pemampat dan kemudiannya dipotong mengikut spesifikasi tertentu berdasarkan piawaian ujian ASTM. Pada permulaannya, spesimen-spesimen diuji pada Analisa Sifat Kritikal iaitu ujian tegangan. Formula sebatian terbaik komposit didapati pada peratusan berat (wt%) dengan 60wt% matrik PP dan 40wt% gentian kenaf. Analisa lanjutan pelbagai sifat mekanik komposit diteruskan terhadap semua formula sebatian. Struktur mikro pada permukaan spesimen yang telah retak dikaji dalam memahami sifat rekahan, taburan gentian dan morfologi permukaan serta hubungannya terhadap kajian sifat mekanik. Keputusan menunjukkan bahawa dengan peningkatan pertambahan gentian telah meningkatkan sifat-sifat mekanik komposit. Pengenalan *polypropylene-graft-maleic anhydride*, (MAPP) dilakukan terhadap formula sebatian terbaik komposit yang menunjukkan penambahbaikan terhadap lekatan antara muka di antara matrik-gentian melalui pemerhatian morfologi dan juga peningkatan sifat mekanik komposit terutamanya sifat penyerapan air. Melalui kajian ini juga, penambahbaikan terhadap sifat mekanik komposit diharap dapat diaplikasikan dengan penggunaan di dalam industri melalui kelebihan pencapaian dalam sifat tegangan, sifat lenturan dan sifat hentaman komposit.

DEDICATION

For my beloved family and friends

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

200x	-	200 times magnification
%	-	Percent
^0C	-	Degrees Celsius
P	-	Density
σ/ρ	-	Tensile Strength per unit mass (specific strength)
E/ρ	-	Tensile Modulus per unit mass (specific modulus)
-OH	-	Hydroxyl
AMPTES	-	3-aminopropyl-triethoxysilane
APS	-	3-aminopropyl-triethoxysilane
ASTM	-	American Society for Testing and Materials
CCC	-	Carbon-Carbon Composite
CMC	-	Ceramic-Matrix Composite
E_{cL}	-	Longitudinal Young Modulus of Composite
E_{cT}	-	Transverse Young Modulus of Composite
eg.	-	Example
et al.	-	and others
etc.	-	Et cetera
FRP	-	Fiber-reinforced plastics
g/cm^3	-	Gram per Centimeter Cube
GPa	-	Giga Pascal
i.e.,	-	That is
J	-	Joule
Kw	-	Kilowatt
(M)	-	Malaysia
MAPP	-	Maleic-Anhydride Grafted Polypropylene
MAPP	-	Polypropylene-graft-maleic anhydride

min	-	Minutes
mm	-	Milimeter
mm/min	-	Milimeter per minute
µm	-	Micrometer
MMC	-	Metal-Matrix Composite
MPa	-	Mega Pascal
N	-	Newton
NF	-	Natural Fiber
N/mm^2	-	Newton millimeter square
NaOH	-	Sodium Hydroxide
OH	-	Hydroxyl
PE	-	Polyethylene
PLLA	-	Poly-L-lactic acid
PMC	-	Polymer Matrix Composite
PP	-	Polypropylene
PP/kenaf	-	Kenaf Fiber Reinforced Polypropylene Composite
PS	-	Polystyrene
RoM	-	Rules of Mixtures
rpm	-	Revolution per minute
SEM	-	Scanning Electron Microscope
UTM	-	Universal Testing Machine
UV	-	ultraviolet
wt%	-	Percent of weight fraction

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Recently, the used of fiber-reinforced plastics (FRP) composite becomes famous in manufacturing industry. The primary advantages of using fiber as filler/reinforcement in plastics are low densities, non abrasive high filling levels possible resulting in high stiffness properties, high specific properties, easily recyclable, the fibers will not fractured when processing over sharp curvatures, biodegradable, low energy consumption and low cost of production (Kahraman *et al.,* 2005). Throughout its performance, FRP composites play a vital role in consumer needs or products that exhibits high level of mechanical properties. The main purpose of using the FRP composites is to improve the mechanical properties of existing polymeric materials. The FRP composite can be defined as a material consists of polymer such as Polypropylene (PP), Polyethylene (PE), Polystyrene (PS) and etc. as matrix and fiber as reinforcement. Each matrix or reinforcement type can be distinct because of its physical or mechanical properties, materials form and chemical composition.

Products in a monolithic material are widely used in a daily life such as bottle, food packaging, vehicles, piping, electronic and etc. These examples of plastics product were specifically produced by using PP, PE, and PS. However, the manipulation of monolithic polymer materials as daily life products are not exhibits the high performances especially in vehicles and electronics application. High impact resistance is necessary for vehicles and high melting temperature is needed for electronic part

(Paul *et al.,* 2008). Melting temperature for PP which is 175ºC has proved that it is not suitable to be used in electronic and engine vehicles which commonly operated at higher temperature of service (Kalpakjian and Schmid, 2006; Callister, 2003). Therefore, the introduction to the fabrication of composites which utilizes the advantages of fiber reinforcement should capable to improve the performances compare to monolithic polymeric material, especially in highly demanding application like automotives and electronics application.

There are two types of fiber commonly used in composites which are natural fiber and synthetic fiber. Both types of fiber got higher potential to be used as a reinforcement agent in composite materials. For low cost of production and widely availability of fiber, natural fiber had been chosen for this study. Natural fiber had played important roles in enhancing the composites performance. Kenaf, Jute, and Hemp namely as natural fiber were widely used as reinforcement for composites. In addition, the performance of the natural fiber, especially kenaf has proved by researchers previously as the multipurpose used materials because of kenaf plant itself include the stalks (bast and core), leaves and seeds to be produced as useful material in manufacturing industry. Beyond the new uses for kenaf including its utilization in building material, absorbents, household, and vehicles, the commercial success of kenaf has great potential economic and environmental benefits in replacement or reduced use of fiberglass in industrial products and the increased used of recycled plastics (Webber *et al.,* 2002). However, there were also disadvantages of using natural fiber in thermoplastics through its ligno-cellulosic properties which are the high moisture absorption of the fibers and the low processing temperature permissible during the fabrication process (Sanadi *et al.,* 1995).

In order to increase the performances and properties of fabricated composites, the compatibilizer should be introduced. Various types of chemical reagents have been used in previous study by researchers such as silane, Maleic-Anhydride Grafted Polypropylene (MAPP), alkoxysilane and etc. Besides the using of Silane, Maleated coupling agents are widely used as its main function to enhance the interactions between the matrix and fiber and to strengthen composites containing fillers and fiber reinforcement (Keener *et al.,* 2004). Therefore, the introduction of MAPP as compatibilizer has been employed through the study in order to improve the mechanical properties of the fabricated composites.

1.2 Problem Statements

It is important and possible to produce a new types of material that exhibit the economically and environmentally benefits for the applications in automotive, building, furniture and packaging industries. By combining the different resources, it is possible to blend, mix or process the natural fiber with other elements such as glass, plastics and synthetics material to produces new classes of materials (Sanadi *et al.,* 1990). Biodegradable or environmentally acceptable materials have attained increasing interest in few decades to the researchers and manufactures due to the environmental pressure derived from the consumption of petroleum-based materials, difficulties in degrade in a landfill and composting environments (Liu *et al.,* 2006; Huda *et al.,* 2007). Thus, the introduction of natural fiber such as kenaf, hemp, ramie and flex has attractively influenced the production of biodegradable materials lately, especially in manufacturing industry (Bledski *et al.,* 2002).

Natural fiber like kenaf can be used as replacement to the conventional fiber. Global environmental issues have led to a renewed interest in bio-based materials like fiber glass or carbon fiber; which the focus on renewable raw materials can be biodegradable or recyclable at reasonable cost (Hong *et al.,* 2007; Zampaloni *et al.,* 2007). The problem faced by the researchers and manufacturers is to find the good natural fiber for polymer composite application equipped with the most promising and outstanding mechanical and physical properties. The uses of natural plant fibers as a reinforcement materials to replace synthetic fibers is receiving great attention, due to the advantages of renewability, low density and high specific strength (Ochi, 2008). These fiber outstanding properties such as high specific strength in stiffness, impact resistance, flexibility, and modulus make them an attractive alternative over the traditional materials (Sgriccia *et al.,* 2008). Specifically, the good properties of kenaf fiber include good specific strengths and modulus, economical viability, low density and low weight has make them as a reinforcement of choice by industry.

The low processing temperature permissible to the ligno-cellulosic fiber in thermoplastics is limited due to fiber degradation at higher processing temperatures (Sanadi *et al.,* 1995). It is important to ensure that the fabrication are employed in the controlled temperature processing, because the degradation of the kenaf fiber will lead to the failure or poor performance to the properties of the fabricated composite. Therefore, the chosen suitable processing temperature is important consideration accordance to the fabrication of PP/kenaf composites.

1.3 Objectives

The purpose of this study is:

a) To study the effects of different fibers loading of kenaf (wt %) to the mechanical properties of the fiber reinforced polypropylene composite;
b) To study the effects of proposed compatibilizer on the fabrication of PP/kenaf fiber and compare its effect to the properties enhancement of the fabricated composites.

1.4 Hypotheses

i). The different filler loading or proportion of kenaf short fiber used for this study will affect the mechanical properties of the composite. It is expected that, by increasing the proportion of filler loading, mechanical properties of the fabricated composite must be also increased correspondingly in accordance with the rules of mixture theory.

ii). Introduction of compatibilizer in this study will increased the mechanical properties of the fabricated composites. The good interfacial adhesion formed between the surface interaction of kenaf fiber and PP matrix is expected to improve the properties of composites materials.

1.5 Scope of study

The study was started by preparing and characterizing the kenaf fiber as raw materials to be used as reinforcement material in the fabrication of PP/kenaf composite. The materials used that related in this study are polypropylene (PP) pellets and kenaf short fibers. The kenaf short fibers were prepared by using the rotor mill to get the various size of fiber length. The size and density of the fiber reinforced were determined by using Scanning Electron Microscope (SEM) model EVO 5 and Electronic Densimeter model MD300-S, respectively. However, the kenaf properties are difficult to measure, thus no preliminary study on the kenaf properties was carried out during this research (Sanadi *et al.,* 1995).

Next stage of process involves the drying study of kenaf fiber. Kenaf fibers will be dried in the drying oven for seven hours period of time and the weight losses of fibers were weighed for every hour. The effects of fiber loading for kenaf short fiber on polypropylene composites were investigates by varying the weight percentage (wt%) for both materials. There are five fraction of fiber loading will be employed in this study