THE EFFECT OF COUPLING AGENT ADDITION TO THE MECHANICAL PROPERTIES OF WOOD PLASTIC COMPOSITE (WPC) MADE OF RECYCLED HIGH DENSITY POLYETHYLENE (RHDPE) AND RECYCLED WOOD FLOUR (RWF)

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

by

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TAJUK: **The Effect of Coupling Agent Addition to the Mechanical Properties of Wood Plastic Composite (WPC) Made of Recycled High Density Polyethylene (RHDPE) and Recycled Wood Flour (RWF)**

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Date	:	25th MAY 2010

APPROVAL

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

…….

(MR. JEEFFERIE BIN ABD RAZAK)

ABSTRACT

The main focus in this research is to investigate the effect of coupling agent addition in various percentages (0%, 3%, and 6% of total weight) to the mechanical properties of wood plastic composite (WPC). 3-Aminopropyl Triethoxysilane is chosen as the coupling agent in this research. Besides, WPC is fabricated by virgin HDPE as matrix phase, recycled plastic packaging bag (PPB) as additional matrix and reinforcement, and wood flour as reinforcement. By the way, the ratios of HDPE to wood flour are 9:1, 8:2, 7:3, and 6:4. There are three different group of WPC fabrication; that are normal WPC, WPC with coupling agent (CA) addition, and WPC with CA and PPB addition. Single way and two ways process method were used in this research where two ways method includes the pre-mixing process by using extruder whereas single way method does not. Next, the composite pallet was formed into composite plate through hot press process. After that, the composites are mechanically tested with flexural test, impact test, and tensile test. Finally, the fracture surface of tensile specimens was analyzed by observing through the Optical Microscopy (OM) observation.

ABSTRAK

Fokus utama dalam kajian ini adalah untuk mengkaji kesan penambahan agen pengkupel dalam pelbagai peratusan (0%, 3%, dan 6% daripada berat keseluruhan) ke atas ciri-ciri mekanikal komposit kayu plastic (WPC). "3-Aminopropyl triethoxysilane" telah dipilih sebagai agen pengkupel dalam kajian ini. Selain itu, WPC adalah diperbuat daripada HDPE dara sebagai matriks, plastik bag kitar semula sebagai matriks dan tetulang berlebihan, dan serbuk kayu sebagai bahan tetulang. Di samping itu, nisbah HDPE dan serbuk kayu adalah 9:1, 8:2, 7:3, and 6:4. Tiga kumpulan akan dikenalkan, iaitu komposit kayu plastik yang biasa, komposit kayu plastic yang ditambah dengan agen pengkupel, dan komposit kayu plastic yang ditambah dengan agen pengkupel dan plastik bag kitar. Proses pembuatan komposit kayu plastic dibahagikan kepada kaedah satu arah dan kaedah dua arah di mana kaedah dua arah mempunyai proses pemcampuran yang menggunakan ekstruder tetapi kaedah satu arah tidak ada. Selepas itu, pelet komposit akan dijadikan plat komposit melalui proses tekanan panas. Kemudian, komposit ini diuji secara mekanikal dengan ujian pelenturan, ujian hentaman, dan ujian lenturan. Akhirnya, permukaan bahagian patah daripada ujian lenturan telah dikaji dengan menggunakan pemerhatian mikroskop optikal (OM).

DEDICATION

To my beloved aunty, your love and support are my greatest inspiration. Without your love and support, I could never go so far until now.

To my friends, it is for your sacrifices, encouragement, and support.

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LIST OF ABBREVIATIONS

ABS	-	Acrylonitrile Butadiene Styrene
Al	-	Aluminum
CA	-	Coupling agent
DSC	-	Differential Scanning Calorimeter
FTIR	-	Fourier Transform Infrared Spectroscopy
HDPE	-	High Density Polyethylene
LPA	-	Laser Particle Analyzer
LDPE	-	Low Density Polyethylene
LLDPE	-	Linear Low Density Polyethylene
MA	-	Maleic Anhydride
MA-PE	-	Maleated Polyethylene
MAPP	-	Maleated Polypropylene
MDPE	-	Medium Density Polyethylene
MPa	-	Mega Pascal
N	-	Newton
PE	-	Polyethylene
PET	-	Polyethylene Terepthalate
PMPPIC	-	Polymethylene-Polyphenyl-Isocyanate
PP	-	Polypropylene
PPB	-	Plastic packaging bag
rHDPE	-	Recycled High Density Polyethylene
RPP	-	Recycled Polypropylene
RT	-	Room Temperature
SA	-	Sauna
SEM	-	Scanning Electron Microscope
TM	-	Tensile modulus
TS	-	Tensile strength
UTM	-	Universal Testing Machine
WF	-	Wood flour
WPC	-	Wood plastic Composite

X-dry	-	Crosslinking-Dry
X-wet	-	Crosslinking-Wet

CHAPTER 1
INTRODUCTION

1.1 Background

Wood plastic composite (WPC), the combination of wood fiber and polymer has been a growing interest in the development of construction and automotive industrial over the past decade. Recently, WPC applications have been extended other than automotive industry such as siding, fencing, window frames and decking. The reasons behind are that the WPC are low density, high stiffness and strength, low price, environmental friendly, less-abrasive to processing equipment, renewable, recyclable, and biodegradable. Other than that, the industries were forced by the environment awareness of people nowadays to choose natural materials as substitutes for non-renewable materials.

The main drawback in WPC production are difficult to achieve strong interfacial adhesion between wood fiber and polymer since they are hydrophilic and hydrophobic material just like water and oil which cannot be mixed together. This will leads to composites with poor durability and mechanical properties. Meanwhile, there has been a lot of researchers come across this problem by introducing coupling agent into the WPC production. From their study, they found out that the coupling agent addition will strengthen the material in terms of mechanical, surface, water absorption, etc. (Bengtsson and Oksman, 2006), (Felix and Gatenholm, 1991), (Kazayawoko *et al.,* 1999), (Kokta *et al.,* 1989), (Maldas and Kokta, 1994), and (Raj, 1989).

In the processing of WPC, there are two important topics shall be clearly identified as basic approach toward WPC design value determination. The first topic is the processing method which includes compounding and forming, whereby the second topic is the specific formulation of WPC parameter such as the composition of wood fiber and coupling agent. These two approaches can help to optimize the WPC mechanical properties to suit the particular application.

1.2 Problem Statement

Mankind, the unique race that exists in the earth has been a large leap in development. Due to the rapid development, million tones of waste per annum are produced from household, commercial, and industrial. Polymer waste such as polyethylene (PE) is the most likely material to be found in dumpling area. Furthermore, this material takes thousand years for degradation in the dumpling area. This was lead to the problem of insufficient dumpling area, and thus, more landfills have to be created to meet the requirement year to year. Consequently, it will cause bad scenery to the environment and ecosystem, contribute to various diseases, and also contribute to global warming.

According to the research of US Environmental Protection Agency (2006), it claims that the worldwide production of plastics is approximately 100 million tones per annum. Attempts have been taken to recycle the post consumer thermoplastic material in order to reduce the impact to the environment and also to reduce the uses of virgin polymer. In the previous research of Nantha (2008), the recycled high density polyethylene (rHDPE) from post consumer milk bottles were successfully recycled to produce wood plastic composite (WPC). It is because the properties of this rHDPE are not significantly different from those virgin resins, and therefore, it could be used for various applications. However, the complicated post consumer product such as plastic packaging bags are not easy to be recycled because it has combined the plastics and metal (typically aluminum foil) material. In order to separate the plastic from metal, various processes have to be implemented, and hence, it leads to high cost. In short, separating the polymer material from the metal layer in plastic packaging bags is impossible.

In regard to the above problem, an alternative way to recycle the plastic packaging bags should be taken. Since the separation of polymer and metal layers in plastic packaging bags are impossible, the alternative way is to recycle and use both materials in one application. This could be done by mixing the plastic packaging bags material into the WPC parameter where the polymer layer will become the matrix and metal layer will act as additional filler which may further strengthen the mechanical properties of WPC.

1.3 Objectives

(a) To investigate the effects of coupling agent in various percentage addition to the mechanical properties of wood plastic composite (WPC).
(b) To study the effects of recycled woof flour percentage and recycled plastic packaging bag material percentage addition in WPC to the mechanical properties of WPC.
(c) To evaluate the effects of different process method to the mechanical properties of WPC.

1.4 Scope

This research will include the processing of WPC through single way method and two ways method where two ways method involves the pre-mixing process by using extruder whereas the single way method does not. Meanwhile, the material characterization process is conducted to analyze the wood flour size, wood flour density, and plastic packaging bag (PPB).

Meanwhile, flexural test (ASTM D790-03), impact test (ASTM D 6110 – 04), and tensile test (ASTM 3039/D3039M-00) will be conducted to analyze the mechanical properties of produced WPC. After that, fracture surface morphology analysis will be taken on the failure specimens from tensile test by using optical microscope.

Besides, the materials involved are recycled PPB, wood flour, Silane, and virgin HDPE granules. The specific formulation of WPC will only focus on the absence and presence of coupling agent (CA), and the presence of PPB with CA. Besides, the HDPE to WF ratios are set to 9:1, 8:2, 7:3, and 6:4. The detail formulations will be discussed in methodology section.

By the way, water absorption test, thickness swelling test, degree of crosslinking test will not be included in this research. The main focus will be on the mechanical properties of WPC fabricated by 25 specific formulations.

1.5 Benefits of Study

From the analysis in this research, a lot of benefits and information could be acquired for example:

(a) Silane percentage addition in optimizing the mechanical properties of WPC.
(b) Wood flour percentage addition effect to mechanical properties of WPC.
(c) Alternative way to recycled complicated polymer material such as plastic packaging bags.
(d) Recycled plastic packaging bag material usage in WPC and its effect to mechanical properties of WPC.
(e) WPC processing methods, steps, and parameter setup.

The future researchers can refer to this research work as a guideline in their WPC research field or alternative way to recycled plastic waste.