

**PROPERTIES OF WATER HYACINTH FIBERS
(*EICHHORNIA CRASSIPES*) FILLED LOW DENSITY
POLYETHYLENE/ACRYLONITRILE BUTADIENE
STYRENE COMPOSITES**

AHMED SALEEM OLEIWI AL-KHUZAIE

UNIVERSITI MALAYSIA PERLIS

2009



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DENSITY POLYETHYLENE/ACRYLONITRILE
BUTADIENE STYRENE COMPOSITES**

by

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2009

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

In the name of Allah the Most Gracious and The Most Merciful.

With the Selawat and Salam to Prophet Mohammad SAW.

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DECLARATION OF THESIS

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ABSTRAK

Keladi bunting banyak terdapat dalam sungai tempatan. Serat keladi bunting (WHF) telah digunakan sebagai komponen penguat untuk polietilena ketumpatan rendah (LDPE) dan akrilonitril butadiena stirena (ABS). Rawatan secara kimia menggunakan isoporon diisocianat (IPDI) dan 1,4-butanadiol telah dijalankan untuk mengubahsuaikan sifat serat. Kesan pembebanan pengisi dan IPDI-poliol sebagai agen pengganding terhadap sifat mekanikal, morfologi, kelakuan pembengkakan, sifat haba dan peruraian secara haba telah dikaji. Komposit tersebut telah disediakan dengan menggunakan Z-blade pengadun pada suhu pemrosesan 200°C dan kelajuan rotor 50rpm dan sampel yang telah dicampurkan kemudiannya dimampatkan dengan menggunakan tekanan hidraulik secara pemanasan elektrik pada suhu yang sama untuk membentuk komposit sampel dalam bentuk kepingan. Secara umumnya, hasil kajian menunjukkan komposit LDPE/ABS/WHF dengan IPDI-poliol sebagai agen pengganding menunjukkan sifat mekanikal dan rintangan penyerapan air yang lebih baik berbanding dengan komposit LDPE/ABS/WHF tanpa IPDI-poliol. Mikrograf permukaan patah kekuatan tensil menunjukkan sifat komposit serat yang dirawati mempunyai penyebaran pengisi dalam matrik yang lebih baik dan tertanam ke dalam matrik berbanding dengan komposit serat tanpa rawatan. Juga telah didapati bahawa serat keladi bunting yang diubahsuai menawarkan kestabilan haba yang lebih baik dalam komposit LDPE/ABS/WHF berbanding serat keladi bunting tanpa diubahsuai.

***Properties of Water Hyacinth Fibers (Eichhornia crassipes) Filled Low Density
Polyethylene /Acrylonitrile Butadiene Styrene Composites***

ABSTRACT

The water hyacinths are largely available in local rivers. In this research, the water hyacinth fibers have been used as reinforcing components for low density polyethylene (LDPE) and acrylonitrile butadiene styrene (ABS). The chemical treatment using Isophorone diisocyanate (IPDI) and 1, 4-butanediol were carried out to modify the fiber properties. The effect of filler loading and IPDI-polyol as a coupling agent on mechanical properties, morphology, swelling behavior, thermal properties and thermal degradation were investigated. The composites were prepared by using Z-blade mixer at processing temperature 200 °C and rotor speed 50 rpm and mixed samples were then compressed by using a hydraulic hot press at the same temperature to form sheet samples composites. Generally, the results indicated that LDPE/ABS/WHF composites with IPDI-polyol as a coupling agent showed better mechanical properties and water absorption resistance than LDPE/ABS/WHF composites without IPDI-polyol. Micrograph of tensile fractured surface shows that the properties of modified fibers composites have better filler dispersion in matrix and embedded fiber into the matrix compared to unmodified fiber composites. It was also found that the modified WHF offers better thermal stability in the LDPE/ABS/WHF composites than unmodified LDPE/ABS/WHF composites.

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LIST OF SYMBOLS, ABBREVIATIONS OR NUMENCLATURE

LDPE	Low Density Polyethylene.
ABS	Acrylonitrile–Butadiene–Styrene.
PP	Polypropylene.
PE	Polyethylene.
PC	Polycarbonate.
PEO	Poly (ethylene oxide).
POE	Poly oxyethylene.
WHF	Water Hyacinth Fiber.
IPDI	Isophorone diisocyanate.
ISS	Interfacial Shear Strength.
OPW	Oxidized Polyethylene Wax.
PHB	Polyhydroxybutyrate.
PET	Polyethylene Terephthalate.
MAH	Maleic Anhydride.
TGA	Thermogravimetry Analysis.
SEM	Scanning Electron Microscopy.
ICI	Imperial Chemical Industries.
MW	Molecular Weight.
MWD	Molecular Weight Distribution.
HDPE	High-Density Polyethylene.
LLDPE	Linear Low Density Polyethylene.
VLDPE	Very-Low Density Polyethylene.
HMWHDPE	High Molecular Weight HDPE.
UHMWPE	Ultra High Molecular Weight Polyethylene.
ULDPE	Ultra Low Density Polyethylene.
g	Gram.
PEMAH	Polyethylene graft maleic anhydride.
PEAA	Poly(ethylene-co-acrylic acid).

PS	Polystyrene.
PVC	Poly (vinyl chloride).
rpm	Rotations per minute.
SAN	Styrene acrylonitrile.
FDT	Final Decomposition Temperature.
MFI	Melt Flow Index.
phr	Per hundred resin.
TG/DTA	Thermogravimetry / Differential Thermal Analyzer.
UTM	Universal Tensile Machine.
PEG	Polyethylene glycol.
DSC	Differential scanning calorimetry.
EB	Elongation at Break.
°C	Degree Celsius.
wt %	Weight percent.
min	Minute.
mm	Millimeter.
ASTM	American Standard Testing Material.
Q_t	The molar absorption.
T_g	Glass transition temperatures.
T_m	Melting temperature.
$\Delta H^{\circ}f$	Enthalpy of fusion.
J	Joule.
FTIR	Fourier Transform Infrared Spectroscopy.
W_i	Weight of the dry specimen.
W_t	Weight of wet specimen.
μm	Micrometer.

CHAPTER 1

INTRODUCTION

1.1 Background

Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable alone (Hull & Clyne, 1996). Wood is natural three-dimensional polymeric composite and consists primarily of cellulose, hemicellulose and lignin. In addition, wood is an original and natural composite. The biological world offers other examples of composites in bone and teeth, which are essentially composed of hard inorganic crystals in a matrix of tough organic collagen (Bledzki, et al., 1998).

Since the 1970s, the application of composites has widely increased due to development of new fibers such as carbon, boron and aramids, and new composite systems with matrices made of metal and ceramics. For the sake of simplicity, however,

composites can be grouped into categories based on the nature of the matrix each type possesses. Methods of fabrication also vary according to physical and chemical properties of the matrices and reinforcing fibers (Amar, et al., 2005)

The Low Density Polyethylene (LDPE) is the dominant type of PE and the most commonly used. It finds its greatest use in film form as a basis for bag making. LDPE is readily heat sealed and is also the cheapest type of PE. The range of low density PE includes those with a variety of slip and antiblock agents, such as required in bulk packaging where low slip for good stackability is needed. Bags for soft goods, where high slip is desired for easy packing, are other applications of LDPE. Low density polyethylene is flexible and tough. LDPE is defined by a density range of 0.910 - 0.940 g/cm³. It is unreactive at room temperatures, except by strong oxidizing agents, and some solvent cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. Made in translucent or opaque variations, it is quite flexible, and tough to the degree of being almost unbreakable. LDPE has more branching (on about 2% of the carbon atoms) than HDPE, so its intermolecular forces (instantaneous-dipole induced-dipole attraction) are weaker, its tensile strength is lower, and its resilience is higher. Also, since its molecules are less tightly packed and less crystalline because of the side branches, its density is lower. LDPE contains the chemical elements carbon and hydrogen.

Thermoplastics reinforced with special wood fillers are enjoying rapid growth due to their many advantages; lightweight reasonable strength and stiffness. Some plant proteins are interesting renewable materials, because of their thermoplastic properties

(Bledzki & Gassan, 1999). Wheat gluten is unique among cereal and other plant proteins in its ability to form a cohesive blend with viscoelastic properties once plasticized (Marion, et al., 2003). It has been found to be an important source of fiber for composites and other industrial applications. Sharifah, et al. (2005) studied the mechanical properties of composites manufactured from polyester resin with Kenaf fiber that blows to a high of at least 10 meter. Traditionally, hemp has been used to make ropes but these days its fiber is used to make items such as clothing, toys and shoes. The fiber is fully biodegradable, is non-toxic and may be recycled.

The advantage of ABS is that this material combines the strength and rigidity of the acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber. The most important mechanical properties of ABS are resistance and toughness. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. The impact resistance can be amplified by increasing the proportions of polybutadiene in relation to styrene and also acrylonitrile although this causes changes in other properties. Impact resistance does not fall off rapidly at lower temperatures. Stability under load is excellent with limited loads. Even though ABS plastics are used largely for mechanical purposes, they also have good electrical properties that are fairly constant over a wide range of frequencies. These properties are little affected by temperature and atmospheric humidity in the acceptable operating range of temperatures (Harper, 1975). The final properties will be influenced to some extent by the conditions under which the material is processed to the final product; for example, molding at a high temperature improves the gloss and heat resistance of the product whereas the highest impact resistance and strength are obtained by molding at low temperature.

Natural fibers as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. They are environmentally friendly, fully biodegradable, abundantly available, renewable and cheap and have low density. Plant fibers are light compared to glass, carbon and aramid fibers. The biodegradability of plant fibers can contribute to a healthy ecosystem while their low cost and high performance fulfils the economic interest of industry. Natural fibers have many significant advantages over synthetic fibers. Currently, many types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, barley, oats, rye, can (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, pennywort, kapok, paper mulberry, banana fiber, pineapple leaf fiber (Bledzki & Gassan, 1999). There are different types of organic fillers added into polyethylene, polypropylene, and other thermoplastic. Several different natural organic fillers such as wood fibers and flour, kenaf fibers, sago, corn starch and pineapple-leaf fibers, had been used as filler in polymer matrices. The adding of filler into polymer will affect the mechanical properties, thermal properties and water sorption of the composites. In addition, the properties of the composites are varied from the pure polyethylene due to different filler types, shape, dimension, percentage of filler loading and the percentage of coupling agent.

Therefore, all natural fibers are hydrophilic in nature and serve most disadvantage factor by considering of these natural fibers is the poor compatibility between the mainly hydrophobic polymer-matrix and hydrophilic fibers. This lead to the formation of a weak interface, which results in poor mechanical properties, where the stress transfer at the interface between two different phases is determined by the

degree of adhesions (Habibi, et al., 2008). Fibers also faced another problem, moisture uptake whereby during service, polymeric materials are subjected to a variety of environmental conditions such as moisture, solvent, oil, temperature, mechanical loads and radiation. Though the moisture absorbed may reduce the bond strengths by breaking the bonds of structure. George et al. (1997) reported, that the rate of water pick up and total amount of moisture absorbed depend on the total amount of moisture absorbed not only plasticizes the matrix resin but also change the state of stress in favor of cracking through swelling.

Water hyacinth or its scientific name (*Eichhornia crassipes*), is a free-floating (but sometimes rooted) freshwater plant. Impacts on human health, food security, water and power supplies and natural ecosystem because of its ability to quickly invade and choke freshwater bodies.

Coupling agent plays critical role in the composites. Zadorecki and Flodin (1986) have found that some coupling agents, namely trichloro-striazine and dimethylol melamine can produce covalent bonds between cellulose materials and polymer matrices, leading to modified performance and reduced sensitivity to water. In the George et al. (1997) reported that the addition of isocyanate (6 % by weight of fibers) had reduced the water uptake of the LDPE composites reinforced with pineapple-leaf fibers. It was found that the presence of silane coupling agent had promoted the chemical interaction in the composites of henequen and high density polyethylene (HDPE), (Herrera et al., 2005).

In this study, the water hyacinth fibers (WHF) were obtained from the fresh water hyacinth in Local River. Some of the dried fibers were allowed to undergo chemical treatment by adding Isophorone diisocyanate (IPDI), 1, 4-butanediol as coupling agent, to enhance the mechanical properties, water absorption resistance, thermal stability and improve the interface adhesion between water hyacinth fibers and LDPE/ABS matrix.

1.2 Objective

1.2.1 To study the effect of the unmodified and modified water hyacinth fibers as reinforcement on mechanical properties LDPE /ABS/WHF composites.

1.2.2 To analysis the effect of unmodified and modified of water hyacinth fibers on morphology of tensile fracture surface of LDPE/ABS/WHF composites.

1.2.3 To study the water absorption of LDPE/ABS/WHF composites with and without modification by using swelling behavior test.

1.2.4 To study the effect of unmodified and modified water hyacinth fibers on thermal properties and thermal degradation of LDPE/ABS/WHF composites by using differential scanning calorimetry (DSC) and thermogravimetry analysis (TGA).

CHAPTER 2

LITRETURE REVIEW

2.1 Over view of Polyethylene

Polyethylene (PE) was discovered in 1933 by Eric Fawcett and Reginald Gibson at the British industrial giant, Imperial Chemical Industries (ICI). Although it is more than 70 years since it was produced, it is still a very promising material. It is produced at high pressures and temperatures in the presence of any one of several catalysts, depending on the desired properties of the end-use product. Other structure (leading to long and short branches) may be present, depending on the producer used in the synthesis. PE is the largest volume polymer consumed in the world. It is a versatile material that offers high performance compared to other polymers and alternative materials such as glass, metal or paper (Cornelia & Mihaela 2005).

Polyethylene plastics have the largest volume use of any plastics. They are prepared by the catalytic polymerization of ethylene at high pressure and temperature. Depending on the mode of polymerization or the desired properties of the end-use product, molecular weight (MW), molecular weight distribution (MWD), as well as on the degree and type of branching there can be three basic types of polyethylene: high-

density (HDPE), low-density polyethylene (LDPE) polymers, and linear low-density (LLDPE). Figure 2.1 and 2.2 show structure and branched-chain structure of LDPE.

LDPE is prepared under more vigorous conditions, which result in short-chain branching. LLDPE is prepared by introducing short branching via copolymerization with a small amount of long-chain olefin. Other types of PE product are such as very-low density polyethylene (VLDPE), high molecular weight HDPE (HMWHDPE), ultra high molecular weight polyethylene (UHMWPE) and ultra low-density polyethylene (ULDPE) (Cornelia & Mihaela 2005).

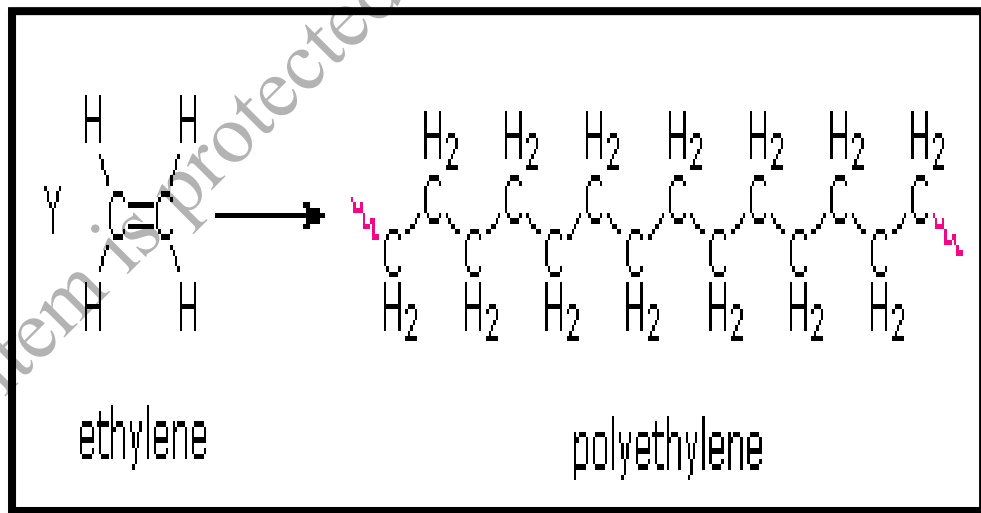


Figure 2.1: Structure of low density polyethylene (LDPE) (Cornelia & Mihaela 2005).

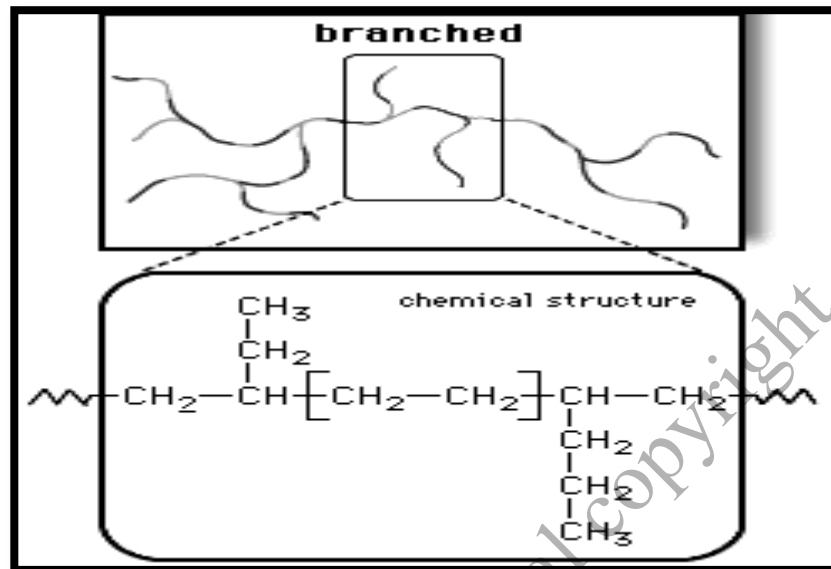


Figure 2.2: Branched-chain structure and chemical structure of LDPE (Cornelia & Mihaela 2005).

2.1.1 Properties of Low Density Polyethylene

LDPE is defined by a density range of 0.910 - 0.940 g/cm³. It is unreactive at room temperatures, except by strong oxidizing agents, and some solvents cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. Made in translucent or opaque variations, it is quite flexible, and tough to the degree of being almost unbreakable.