MECHANICAL CHARACTERIZATION OF POLYMER MATRIX COMPOSITE (LOW DENSITY POLYETHYLENE WITH RUBBER)

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Tarikh : ....25 MEI 2007.........

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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan perikan yang tiap-tiap satunya saya jelaskan sumbernya"

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ABSTRACT

This research is carried out to develop a rubber reinforced polymer composite using polyethylene resin as the matrix material and rubber as the filler. The material under study is the LDPE and tyre industrial waste rubber. The selection of waste rubber as the filler material is inspired by the environmental awareness to find a solution for cleaning and recycling a non biodegradable material. LDPE is recyclable and with good quality and special characteristics and by merging the recyclable and easy to find, industrial waste rubber, with LDPE, hopefully that the better material properties with high quality characterization can be created. This study will contribute on the process of developing the raw material of rubber reinforced polymer via using the internal mixer. After that the specimen sample will be created during the development process by roll milling and hot pressing the specimen sample. Then mechanical test in terms of tensile test is ready to be run. The tests conducted in order to obtain the mechanical properties of the specimen product. Hopefully via creating this brand new polymer matrix composite, the rubber reinforced polymer matrix composite, will give lots of benefits and have more quality against corrosion, wear, and durable and longer life span. This product also may save the world as this product reuses and recycles the industrial waste rubber.

ABSTRAK

Kajian ini di jalankan adalah bertujuan nuntuk menghasilkan komposit polimer yang diperbaharui dengan menggunakan poliethilene sebagai bahan utama dan getah sebagai bahan campuran. Bahan yang dikaji adalah poliethilene berketumpatan rendah dan sisa getah dari industri permbuatan tayar. Pemilihan untuk menggunakan getah datangnya dari kesedaran dan kepekaan terhadapa persekitaran serta alam sekitar dan bertujuan untuk mencari alternatif serta kaedah untuk membersih dan mengitar semula bahan tidah terbiodegradasi iaitu getah. Poliethilene berketumpatan rendah adalah bahan yang boleh dikitar semula dan mempunyai cirri-ciri unik serta istimewa dan dengan menggabungkan kedua-dua bahan ini, maka di harap agar dapat menghasilkan satu bahan jenama baru yang lebih baik dari segi kualiti, dapat dihasilkan. Kajian ini meliputi proses penghasilan bahan polimer baru dalam bentuk adunan dengan menggunakan mesin adunan dalaman. Setelah itu, adunan itu akan bentuk menggunakan mesin tekan bersuhu tinggi dan mesin gelek bagi mendapatkan sampel yang nipis. Kemudian itu sampel tersebut akan dipotong dan akan menjalani ujian mekanikal untuk menentukan cirri-ciri mekanikal yeng terdapat padanya. Akhirnya diharap agar dengan terhasilnya bahan polimer yang baru ini, maka dapat memberi lebih banyak faedah dan kualiti yang tinggi bagi menentang hakisan, kakisan serta mempunyai tempoh jangka hayat gunaan yang lebih lama. Pernghasilan bahan polimer ini juga dapat mengurangkan pencemaran serta menyelamatkan alam sekitar memandangkan bahan ini mengitar semula bahan getah terbuang dari kilang.

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CHAPTER 1

1.0 INTRODUCTION

1.1. INTRODUCTION

Polymer composites are usually used to make very light bicycles that are faster and easier to handle, fishing boats that are resistant to corrosive seawater, and lightweight turbine blades that generate wind power more efficiently. New commercial aircraft also contain more composites than their predecessors and in aircraft industry, now they are designing an aircraft that consist of 25 percent composite and they even more design that half of the body is from composite.

Polymer matrix composite is simply a composite that used polymeric material as it matrix material and being enhanced via using by additive, known as filler therefore polymeric materials usually have high strength, possess a glass transition temperature, exhibit rubber elasticity, and have high viscosity as melts and solution.

Lighter and stronger materials are being designed that can be used at high temperatures and resist corrosion better than conventional metals or plastics in various commercial and military applications. Called polymer matrix composites, these materials consist of strong fibers embedded in a resilient plastic that holds them in place.

In the future, polymer composites could be even tougher and lighter than today's composites. These composites could improve protection against fire, blasts, and bullets for military equipment and personnel.

1.2. PROBLEM STATEMENT

Polymer matrix composites nowadays have become popular because of its advantages and many composite materials had been developed. One of them is the polymer matrix composite, consists of a matrix polymer and filler as the copolymer. For this study, the matrix polymer is the low density polyethylene while the filler is the waste rubber from the tyre manufacturing.

Beside that, there are needs for recycling and reused since there are lots of wastes from rubber and polymer. Yet they are not biodegradable, reusing them become more significant in order to balance and reduce the total waste in this community.

For this study, the rubber used is from the tyre thread bits and the supplies were taken from the tyre manufacturer, the Continental Sime Tyre, Mergong, Alor Setar. This tyre thread bits is a side waste product from the finished tyre, and were going to demolished so is wasted and pollution if the rubber is not to be reused and properly demolished. Beside that by using rubber as the filler for composite material, the composite would improve by having the rubber characterization into the polymer composite blend itself.

1.3. PROBLEM IDENTIFICATION

From the problem statement above, this study had identified that the polymer matrix composite contain of low density polyethylene and rubber filler will be develop and this study will figure out their mechanical characterization in terms of testing, mechanical properties, physical properties and morphology study.

The development of this polymer composite will be using the internal mixer for the material blend sample preparation and for the data collection on the processing of the polymer blend. As for the bulk sample preparation, the single screw extruder will be used since the production is much faster and easier. The material will be transformed into shaped that is suit for the testing machine via the roll milling and hot press then being cut into desired shape. In order to obtain the mechanical properties, this study will be using two types of tests. They are the three point bending and the tensile test.

As many composite materials had been developed, its characterization must be identified in order to justify the suitability and its application of new materials in the future. Beside that the characterization in term of testing, morphology study and the physical properties is vital to be recorded for future usage.

Beside that, in this study the material is the rubber reused from the very waste of tyre thread bits manufacturer and this study will turn the waste and unwanted rubber into a usable recyclable and reusable product.

1.4. OBJECTIVES OF PROJECT

The main objective of this project is to characterize the mechanical properties of the polymer matrix composite in terms of mechanical properties. Besides characterizing the properties of the polymer, this study will be suggest the possible future application for this type of polymer composite development. This study will also determine and identify the effect of reusing rubber on polyethylene at different composition.

1.5. SCOPE OF STUDY

Polymer matrix composite is simply a composite that used polymeric material as it matrix material and it is enhanced by adding some additive named as filler. For this study the polymer matrix chosen is low density polyethylene (LDPE) and the filler is the reused waste rubber. The polymer blend of these materials will be made into several compositions, therefore producing several properties in their characterization later on. The polymer blend will then transformed into the specimen by passing through the process of roll milling and hot pressing and specimen cutting.

A series of tests will be carried out on the polymer matrix composite to practically characterize the properties of it. The properties of it will be seen from the dimension of mechanical properties, physical properties and morphology study. In order to determine the mechanical characteristics, tests will be conducted. The test is the tensile test.

Analysis will be carried out based from the data collected starting from the material choosing, polymer blend processing, the test conducted and until the morphology study. From the result and data discussed, the possible suitable application will be recommenced from comparison with parent material.

The duration of this study to complete is one year and has been divided into PSM1 and PSM2. For the PSM1, this study is focusing on the research related to the field of this project and focusing on the planning for the overall project. For PSM2, the project focusing on executing what had been planned in PSM1. The project progress plan can be seen in the Gantt Chart as in appendix A.

CHAPTER 2

2. LITERATURE REVIEW AND PROCESSING PROCEDURE

2.1. POLYMER MATRIX COMPOSITE

Polymer is a term used to describe molecules consisting of structural units and a large number of repeating units connected by covalent chemical bonds. Anil Kumar et al, in his book Chemical Engineering, Fundamentals of Polymers, defines polymers as a material of very high molecular weight, which usually consists of several structural units bound together by covalent bonds. These structural units are called 'monomer', which is a small molecular compound. Through chemical reaction, repeated linkage of monomers is form to obtain polymer.

As for example, polyethylene is along chain polymer and is represented by

$$CH_2CH_2CH_2\text{-} \quad \text{or} \quad -\!\!\left[CH_2CH_2 \right]_n\!-$$

where the structural (or repeat) unit is –CH2– CH2– and n represents the chain length of polymer. Polymers are obtained through chemical reaction of smaller molecular compounds called monomers. Polymeric materials usually have high strength, possess a glass transition temperature, exhibit rubber elasticity, and have high viscosity as melts and solution.

A 'composite' according to Wikipedia stated that composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct within the finished structure. Composite is a heterogeneous combination of two or more materials (reinforcing agents & matrix), differing in form or composition on a macro scale. The combination results in a material that maximizes specific performance properties. The constituents do not dissolve or merge completely and therefore normally exhibit an interface between one another. According to James K. Wessel, in his Handbook of Advanced Materials-Enabling New Designs, composites definitions are:

i. Made up of distinct parts or elements
ii. A macroscopic combination of two or more distinct materials, having a recognizable interface between them
iii. Two or more materials judiciously combined, usually with the intent of achieving better results that can be obtained by using individual materials by themselves
iv. High strength fiber-primarily continuous, oriented carbon, aramid, or glass rather than randomly distributed chopped fibers or whiskers-in a binding matrix that enhances stiffness, chemical and hydroscopic resistance, and processability properties.

2.2. MATRIX AND FILLER

2.2.1. LOW DENSITY POLYETHYLENE (LDPE) AND RUBBER

In this study, polymer composite used is the combination of the low density polyethylene (LDPE) and rubber. Each represents the matrix and the filler in composite.

Polyethylene is a polymer consisting of long chains of the monomer ethylene. The recommended scientific name 'polyethylene' is systematically derived from the scientific name of the monomer. In certain circumstances it is useful to use a structure–based nomenclature. The difference is due to the 'opening up' of the monomer's double bond upon polymerization.

The ethylene molecule C_2H_4 is $CH_2{=}CH_2$, Two CH_2 groups connected by a double bond, thus:

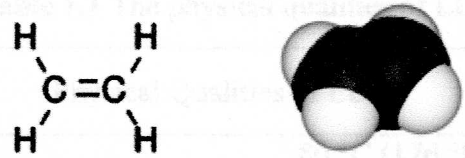

Figure 1.1 Ethylene Molecule and the chemical bond between atoms

Polyethylene is created through polymerization of ethylene. It can be produced through radical polymerization, anionic addition polymerization, ion coordination polymerization or cationic addition polymerization. This is because ethylene does not have any substituent groups which influence the stability of the propagation head of the polymer. Each of these methods results in a different type of polyethylene. As indicated by Wikipedia.

LDPE is defined by a density range of 0 to 3 (0.910 - 0.940 g/cc.) It is unreactive at room temperatures, except by strong oxidizing agents, and some solvents cause its 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 a high degree of short and long chain branching, which means that the chains do not pack into the crystal structure as well. It 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. This results in a lower tensile strength and increased ductility. LDPE is created by free radical polymerization. The high degree of branches with long chains gives molten LDPE unique and desirable flow properties as presented by Wikipedia.

Table 1.1 The physical qualities of LDPE

Physical Qualities of LDPE	
Maximum temperature	80 °C (176 °F)
Minimum temperature	−50 °C (−58 °F)
Melting point	120 °C (248 °F)
Tensile strength	11.7 MPa (1700 psi)
Hardness	SD55
UV resistance	Poor
Density	0.92 g/cm³
Qualities	Autoclavable : No, translucent and excellent flexibility

In terms of chemical resistance, LDPE has excellent resistance (no attack) to dilute and concentrated acids, alcohols, bases and esters and good resistance (minor attack) to aldehydes, ketones and vegetable oils but limited resistance (moderate attack suitable for short term use only) to aliphatic and aromatic hydrocarbons, mineral oils and oxidizing agents.

LDPE is widely used for manufacturing various containers, dispensing bottles, wash bottles, tubing, and various molded laboratory equipment. Its most common use is in plastic bags. Other products made from LDPE includes trays & general purpose containers, food storage and laboratory containers, corrosion-resistant work surfaces, parts that need to be weldable and machinable, parts that require flexibility for which it serves very well, very soft and pliable parts, six-pack soda can rings, extrusion coating on paperboard and aluminum laminated for beverage cartons, plastic film applications such as plastic bags and film wrap and rigid containers.

On the other hand, rubber is an elastic hydrocarbon polymer which occurs as a milky colloidal suspension (known as *latex*) in the sap of several varieties of plants. Rubber can also be produced synthetically. Synthetic rubber is made through the polymerization of a variety of monomers to produce polymers and called as elastomer [Serope Kalpakjian et al]. Elastomers compose a large family of amorphous polymers having a low glass-transition temperature. They have a characteristic ability to undergo large elastic deformations without rupture. They are soft, and they have a low elastic modulus. The structure of these polymers is highly kinked (tightly twisted or curled). They stretch, but then they return to their original shape after the load is removed. Elastomers have a wide range of applications-for example, high friction and non skid surfaces, protection against corrosion and abrasion, electrical insulation, and shock and vibration insulation. Serope et al listing that the examples include tyres, hoses, weather stripping, footwear, linings, gaskets, seals, printing rolls and flooring.

2.2.2. REVISION OF JOURNAL ON PREVIOUS WORK

Recently, the world nowadays is searching for a material that can replace the use of metal and alloys but with the same toughness and resistance to wear, corrosion and environment friendly. As well as the needs, there are lots of researches involving reinforced polymer matrix composite had been done to find the properties and effect of polymer composite.

As stated in the research done by Barone J.R et al (2005), shows that there are interactions between keratin fiber from chicken feathers to reinforcing polyethylene. This interaction between polyethylene and keratin are developed without the coupling agent and even though in this research, the mechanical properties of composites only increased slightly compared to neat polyethylene, Barone suggested that fiber with higher modulus is used to achieve optimum increase in properties. Further research by Barone, indicated that it is imperative to use a fiber of higher modulus, but it is important to have good fiber/polymer interaction to obtain reinforcement from fibers.

According to Barone, in short-fiber reinforced polymer composites, the integrity of the fiber/matrix interface needs to be high for efficient load transfer. Ideally, the molten polymer would spread over and adhere to the fiber, thus creating a strong adhesive bond. Inorganic fibers like glass and cellulosic fibers have hydrophilic surfaces that make them incompatible with hydrophobic polymers. Therefore according to Chawla KK, inorganic and cellulosic fibers usually require chemical modification to increase fiber or polymer interactions.