THE EFFECT OF OIL PALM TRUNK FILLER IN EPOXIED NATURAL RUBBER

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ABSTRACT

The effect of loading oil palm trunk as filler in natural rubber was investigated in this research. The testing that will be made on the reinforced fiber rubber are tensile strength test and swelling test. The natural rubber is obtained from Rubber Research Institute Malaysia (RRIM). There are three types of rubber in this research. They are Epoxied Natural Rubber (ENR), Standard Malaysian Rubber (SMR), and Styrene-Butadiene Rubber (SBR). The selected ENR will be milled on the two roll mill machine and mix with filler after the milling process. The filler will be divided into five different of parts per hundred rubbers (phr). The compounds will be vulcanized with sulfur and ready to be molded. The molded rubber will be tested. The machines that will be used in this research are two roll mill for compounding and hot press machine for molding. Two roll mills will operate for 3 hours per compound. The hot press machine will be used for 25 minutes each molding sessions. Conventional filler is the carbon black filler. Oil palm trunk is used as filler to compare with carbon black filler in terms of rubber properties. It was found out that the higher the amount of oil palm trunk in rubber, the lower the tensile strength of the rubber. The swelling of rubber product is higher in kerosene compare with diesel. When the filler content increase, the mixing time will be increased.

ABSTRAK

Pengaruh bebanan fiber batang pokok kelapa sawit diuji di dalam kajian ini. Antara ujian yang dilakukan pada getah pencampuran fiber adalah ujian kekuatan tegangan dan ujian pengembangan. Getah asli didapati dari Lembaga Getah Malaysia. Terdapat tiga jenis getah yang terdapat di dalam kajian ini iaitu Getah asli epoxied (ENR), Getah asli standard Malaysia (SMR) and Getah sintetik (SBR). ENR yang telah dipilih akan dileperkan menggunakan two roll mill and dicampur dengan pengisi setelah proses penleperan selesai. Pengisi dibahagikan kepada lima bahagian per seratus getah (phr). Campuran tersebut akan divulknanisasi dengan sulfur dan bersedia untuk dibentuk mengikut acuan. Campuran tersebut akan diuji. Peralatan yang digunakan adalah two roll mill untuk pencampuran dan hot press machine untuk pembentukan. Two roll mill akan beroperasi untuk 3 jam setiap sampel. Hot press machine pula beroperasi untuk 25 minut setiap sampel. Pengisi konventional ialah karbon hitam. Dari segi sifat getah, fiber batang pokok kelapa sawit digunakan dan dibandingkan dengan pengisi karbon hitam. Semakin tinggi fiber batang pokok kelapa sawit, semakin rendah kekuatan tegangan getah tersebut. Dalam ujian pengembangan, getah yang direndam dalam minyak tanah lebih kembang berbanding rendaman dalam minyak diesel. Semakin tinggi kandungan fiber batang pokok kelapa sawit, semakin tinggi masa untuk pencampuran.

TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL NAME
CBS	n-cyclohexyl-2-benzothiazyl sulphenamide
6PPD	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylene-diamine
ENR	Epoxied Natural Rubber
PHR	Part per Hundred Rubber

CHAPTER 1

INTRODUCTION

1.0 Background

Carbon black is the predominant filler that is being widely used in reinforcing the rubber compound. Surface area to volume ratio of carbon black is rather low compared to activated carbon. Usually it will increase the thermal properties, the rubber vulcanizates' elastic modulus, tensile strength as well as the increasing of hysteresis. Hysteresis represents the *history* dependence of physical systems (James P. Sethna*et al*, 1999). If the rubber was applied with force, it will bounce back to its initial properties. Generally, this research is to predict the elasticity of a kind of rubber when it is being reinforced by carbon black. Most studies in the experimental are emphasis on (1) the reinforcement obtained within a matrix, (2) The interaction between rubber and the filler and (3) the agglomerate structure (B. Omnes *et al.*, 2008).

In the past, many researchers have conducted various types of experimental works in order to find out the characteristics and the effects of carbon black loaded rubber. There are various types of carbon black existed in the industry. The carbon black examples are such as, N220, N300 and N990. The differences between these carbon blacks are their particle size. In order to choose the best rubber that can be built, we must select the best carbon black in order to increase the strength and elasticity of the rubber. There are other type of fillers in the industry such as oil palm and bamboo filler. In this research, the carbon black has been chosen as the main material in order to run this research.

Natural fibres has widely used in the industry nowadays. The selection of natural fibres is wide. This is depending on the product that need to be produced and the demand of the market. Converting from waste to wealth is a bonus to researchers nowadays. From a waste such as vehicles tire can be converted to rubber product again using several methods that are available. The raw material is cheap and recycled product can be used in the society. Thus, the environmental waste is reduced.

Of course, the properties of rubber product reinforced by natural fibres must be equal or better than the current rubber product in the market. To make sure the product is competitive to be market; the formulation of producing the product is an important factor to make sure the product is saleable.

1.1 Problem Statement

This research has been conducted due to the increase of price of rubber products in the market. This is because the price of the product mostly based on the production cost itself. By cheapening the cost of production, we can reduce the price of rubber products. On the other hand, new formulation is needed to be created. This is where we are using less amount of natural rubber but at the same time, we are going to maintain its crucial properties such as tensile strength and tear strength. In addition, the research on this topic has not been widely conducted around the world. This is to help the industry to have a better selection on the natural fillers. With this research, the advantages and disadvantages of the selected natural fibre could be determined.

In addition, the processability will determine whether the method is usable or not. This is because, processing errors may occur during the manufacturing the rubber product.

1.2 Objective

To load various parts of oil palm trunk fillers in epoxied natural rubber to determine the strength and elongation of the rubber product.

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1.3 Scope of study

This research consists of several main scopes:

- To use oil palm trunk as the filler for rubber
- Use only epoxied natural rubber as the main raw material
- Tensile strength, and swelling will be the testing of this research
- Tensile strength of each rubber product will be studied

1.4 Rational & Significance

Several significances will be found during conducting the research. One of them is the price of rubber product will be decreased. During the running of research, new formulation will be created and the parts of natural rubber will be less in it. Thus, the price of rubber products will be decrease. On the other hand, higher quality of rubber products will be produced. Lastly, the processability will be determined whether this method is usable or not. We can see throughout the research whether this method is suitable or not to run this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Our everyday life has a strong connection with rubber. Most of our equipment is made of rubber inclusive of natural rubber and synthetic rubber. It is the statement that can say that, without rubber our life is not smooth to run its daily schedule. Malaysia is among the biggest producer of natural rubber in the world. The first person to found out rubber is Charles Marie de La Condamine where he found rubber in the year of 1736.

2.1.1 History

In the past, rubber is among the most valuable product that can be found in the forest. It is stated that rubber originally came from South America. Mostly are from Brazil. In 1839, Charles Goodyear accidentally dropped rubber and sulfur on a hot stovetop, causing it to char like leather yet remain plastic and elastic (Wade Davis, 1996). This process is called vulcanization. This is where the rubber has been cross linked with sulfur.

2.2 Types of Rubber

2.2.1 Natural Rubber

The most common form of rubber is in liquid form which is latex. The chemical name of this rubber is poly-isoprene. Natural rubber can be gathered from the rubber tree. The name of this tree is called Heveabrasiliensis. It is also the only non-synthetic elastomer where it is being widely used in the industry. Low temperature can cause natural rubber to be crystallized spontaneously. Because of this, the effect of crystallization can cause stiffness. This process can be reverse by warming up the natural rubber.

Natural rubber has properties such as poor resistance to ozone, high temperatures and also concentrated acids and bases. In order to overcome these types of problems, synthetic rubber is usually mixed with natural rubber. The reasons why this natural rubber is mixed with other type of ingredients is to increase component-to-component adhesion, improving the tear strength of the natural rubber, and lower tire rolling resistance to improve vehicle fuel efficiency (James E. Mark et al, 2005). The crucial property of natural rubber is the elasticity. This is because the natural rubber can be distorted and it can recover to its original shape. NR is not oil resistant and is swollen by aromatic, aliphatic and halogenated hydrocarbons. It is resistant to many inorganic chemicals, but not to oxidizing acids and had limited resistance to mineral acids. It is unsuitable for use with organic liquids in general, the major exception being alcohols of low molecular weight. (Richard Simpson, 2002)

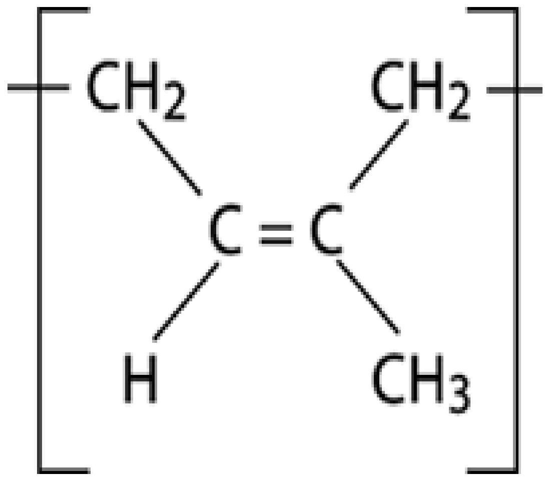

Figure 2.1 Structure of natural rubber taken from (Robin Bartoletti, 2005)

2.2.2 Epoxied Natural Rubber

Epoxied Natural Rubber (ENR) is prepared by chemically introducing epoxied groups randomly onto the NR molecule. This chemical modification leads to increased oil resistance, greater impermeability to gases, but an increase in the glass transition temperature, Tg, and damping characteristics; the excellent mechanical properties of NR are retained.

As stated by M.Pire et al, 2010, the ENR remains the properties of natural rubber while having double functionality for cross-linking. It has the double bond and epoxy sites in the ENR. The degree of epoxidation increases, the glass transition temperature, Tg, increase and lastly the resilience is decrease.

2.2.3 Styrene Butadiene Rubber

Synthetic rubber is another form of rubber where it is produced to replace mainly on the function of natural rubber. This is because the synthetic rubber has a better pricing where it is cheaper than the natural rubber. On the other hand, synthetic rubber is made from polymerization process. Synthetic rubber consumption is mostly in tires where it is around 60% of usage. The most common synthetic rubber that is being widely used is styrene butadiene rubber, is currently called SBR. SBR is a synthetic rubber that reacted from a reaction styrene and butadiene. In tire industry, SBR is added with natural rubber to increase abrasion resistance and it also has good aging stability. In most of the cases, SBR is representing around 65% of the total usage of synthetic rubber used in tires. The process of SBR compounds are similar to the processing of natural rubber and additives are used. SBR is compounded with better abrasion and crack initiation than natural rubber. SBR products are smoother and maintain their shape better compared with natural rubber products.

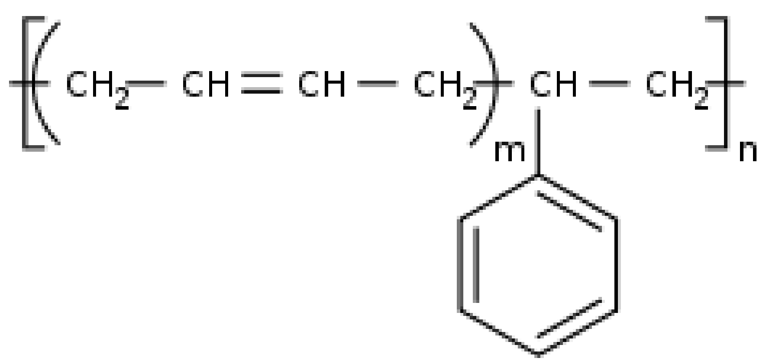

Figure 2.2 Structure of SBR taken from (Luigi Chiesa, 2008)

2.2.4 Cross-linked rubber

Cross-linked are bonds that linked one polymer chain to another. In rubber, the cross linked agent is the sulphur. Sulphur links polyisoprene chain from the upper to the lower chain. It is working as a bridge cross-linking agent. The cross linking of the elastomeric polymer is achieved by an irreversible chemical reaction usually at high temperatures. Increasing the amount of cross-link agent will favour shorter cross-links.

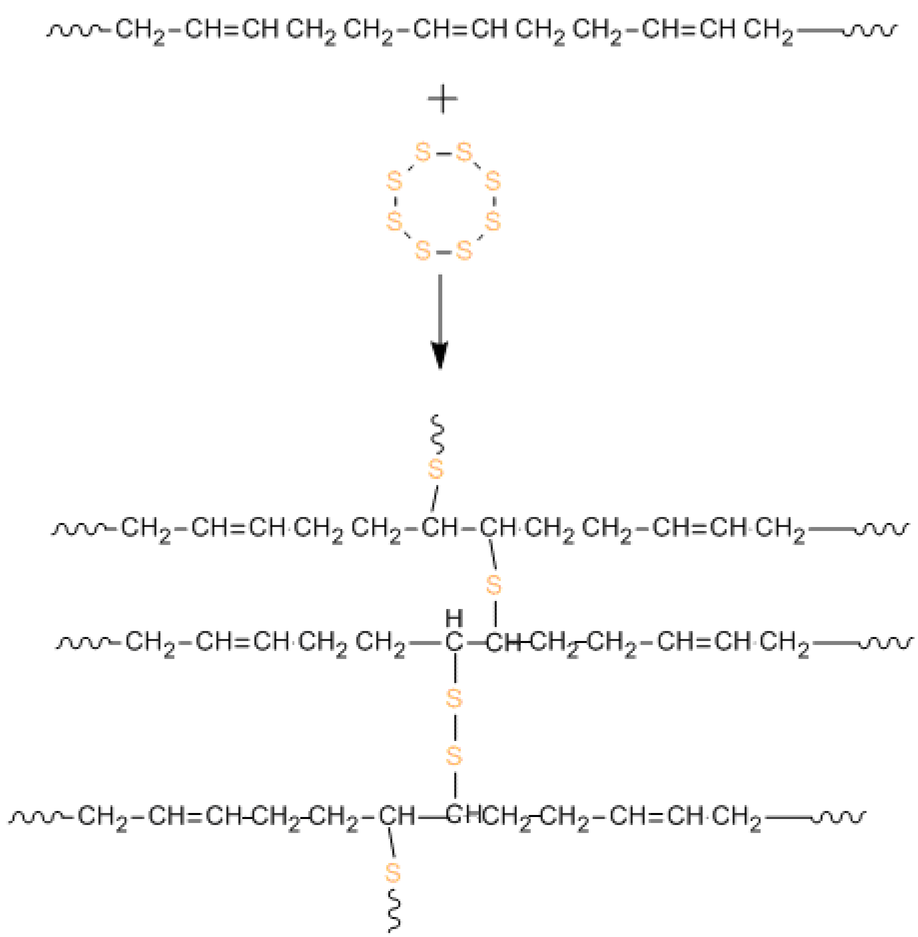

Figure 2.3 Cross-linked Reaction taken from (Nick Greeves et al, 2008)

2.24 Polybutadiene Rubber

By using emulsion process or solution process, polybutadiene can be produced. Polybutadiene rubber is resistance to cold and also excellent in flex properties. This is the reason polybutadiene rubber is useful in blends of two or more polymers. The reason polybutadiene rubber is mixed with fillers are: (1) lack of toughness, (2) lack of durability and (3) cut growth resistance of the latter. The polybutadiene rubber should not blend with polar elastomer. Commonly, polybutadiene rubber is mixed with NR or SBR in order to improve the low temperature flexibility of NR and SBR. Despite its unsaturation, polybutadiene have a fair resistance to oxidation. (R. School., 2001).

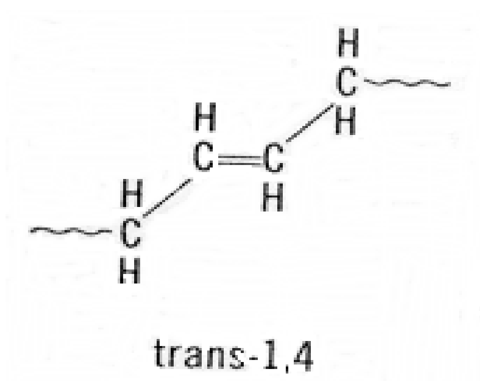

Figure 2.4 Chemical structure of PBR taken from (International Institute of Synthetic Rubber Producers, Inc., 2002)

2.2.5 Ethylene-Propylene-Diene

Ethylene-Propylene-Diene (EPDM) is categorized under specialty elastomer and it is widely used in automotive industries, wire-and-cable covers and many other fields. The main attributes that makes it become special is its resistance to ozone. EPDM can be highly loaded with low cost fillers such as clays and silica. This features makes compounders can rely on EPDM to produce rubber products.

The process of curing EPDM can be done using sulphur or peroxides. Using peroxides as the curing agent would produce products that will meet high heat required application. On the other hand, the resistance of EPDM to aliphatic, aromatic and chlorinated hydrocarbon is very poor. To overcome this problem, the reinforcing agent is added to the process will provide the solution. This is where the reinforcing agent is absorbing the poor resistance of EDPM.

EPDM require reinforcing agent to overcome lack of gum strength. As the loading of reinforcing agent increases, the tensile and tear properties increase. (R. School., 2001).

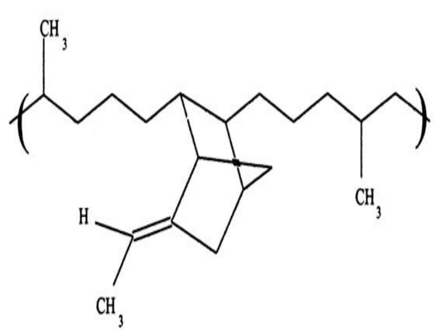

Figure 2.5 Structure of EPDM containing ENB taken from (R.Karpeles et al., 2001)

2.3 Filler

Fillers are things which added into material in order to improve some mechanical properties of a material. Fillers are needed in the rubber compound as it strengthens the rubber itself. There are two types of fillers. They are carbon black and non-carbon black. On the other hand, fillers are compounding ingredients added to a rubber compound for the purpose of either reinforcing or cheapening the compound. For non-carbon black fillers, there are several examples of them. They are fumed silica, clay, ground or precipitated calcium carbonate, titanium dioxide, wood flour, glass, limestone and talc. Fillers will also improve processability, and durability of rubber products. On the other hand, fillers can be used to alter electrical properties, improve heat, tear and moisture resistance. There are several properties of fillers that needed to check before insert it into the rubber. They are particle size, surface area, and structure (Peter A. Ciullo, 1999)

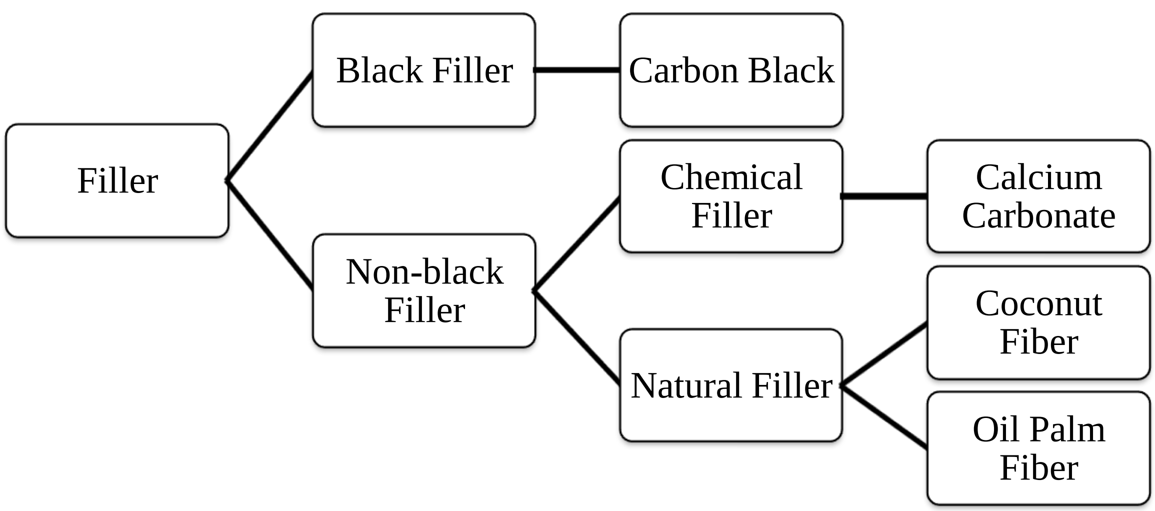

Figure 2.6 Categories of Fillers

2.3.1 Particle Size

Fillers with higher number of particle size can reduce the performance rather than reinforce or extend. The fillers can be classified into 3 classifications. The classifications are non-reinforcing, Semi- reinforcing and reinforcing. The carbon black fillers can be in various particle sizes where the carbon black can be semi – reinforcing and reinforcing.

2.3.2 Surface Area

Fillers that have higher surface area have more contact area with the rubber chain thus contributing to higher potential of reinforcing the rubber chain. Particles of carbon black are usually spherical. Carbon black has the better more surface area per unit weight rather than other type of fillers. Thus, this statement shows that carbon black has a better contribution to reinforce rubber.

2.3.3 Structure

The structure of fillers plays essential part in reinforcing the rubber. High structure filler has aggregates favouring high particle count. The increase of structure size improves dispersibility but lowers blackness. Carbon black with a larger structure in particular shows an excellent conductive property. In addition, the reinforcing potential will be higher if the structure is larger in size.

2.4 Types of Fillers

2.4.1 Carbon Black

Carbon Black is the most common filler that is being used in the industry. There are several processes to produce carbon black. The most and widely used process is the furnace process. The other type of process is to Carbon blacks are produced by converting either liquid or gaseous hydrocarbons to elemental carbon and hydrogen by partial combustion or thermal decomposition. On the other hand, the oldest method for producing the carbon black is using the lampblack process. The lampblack process is consists of a flat cast-iron pan which contain the liquid feedstock. The feedstock required is aromatic oil mainly based on coal tar (Gerhard Kühner et al, 1993). It is also can be stated as method obtains carbon black by collecting soot from fumes generated by burning oils or pine wood. The range of carbon black is from the smallest N110 to the largest N991. The differences between these carbon blacks are their particle size. For the smallest carbon black is average 17nm while the largest carbon black is average 300nm.