DEGRADATION OF PHYSICAL AND MECHANICAL PROPERTY OF STARCH MODIFIED NATURAL RUBBER COMPOSITES

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Submitted in accordance with the requirement of the University Technical Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering

by

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Date : 25 May 2018

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Bachelor Degree of Manufacturing Engineering. The member of the supervisory committee are as follow:

…….....

(Profesor Madya Dr Noraiham Binti Mohamad)

ABSTRAK

Pada masa kini, terdapat begitu banyak aplikasi yang boleh dikaitkan dengan getah asli. Salah satu aplikasi utama ialah pengeluaran tayar. Ini adalah kerana sifatnya yang akan memberi manfaat kepada produk seperti kekuatan tegangan yang tinggi, kekerasan yang tinggi dan mempunyai keadaan ubah bentuk yang tinggi. Sayangnya, apabila tayar tidak boleh digunakan lagi dalam aplikasi kereta, terdapat beberapa cara alternatif untuk menggunakannya sama ada untuk mengurai melalui pembakaran. Kitar semula tayar sampah akan mengurangkan kesan alam sekitar seperti kesan rumah hijau, pencemaran udara dan pencemaran air. Walau bagaimanapun, dalam proses kitar semula, tayar sampah perlu diubah untuk menghasilkan produk baru. Proses keratan, dan lenturan tayar sisa adalah beberapa proses yang diubah. Oleh yang demikian, tujuan penyelidikan ini adalah untuk mengkaji tentang pengaruh kanji penggabungan dengan komposit getah asli. Pada tahap pertama, bermula dengan prosess modifikasi starch dengan silane. Selepas itu, prosess perkompaunan berlaku menggunakan mesin pengadun dalaman. Akhir sekali, mesin penekan panas di gunakan untuk mereka membentukkan sampel tersebut. Untuk proses ini, terdapat dua sampel perumusan yang terdiri daripada kompaun dengan kanji dan tanpa kanji. Sampel perumusan terletak pada dua keadaan yang berada di dalam suhu bilik dan pengebumian tanah. Sampel perumusan dikumpulkan selepas beberapa hari ujian proses 0, 3, 7, 14, dan 28 hari. Dalam ujian tarik, ketumpatan dan kekerasan sedang diuji dalam proses ini. Seterusnya, morfologi sedang dianalisis. Dalam proses ini, beberapa mesin sedang digunakan iaitu mesin SEM, XRD, DMTA dan FTIR. Dari hasilnya, dapat dilihat bahwa kehadiran kanji akan mengakibatkan penurunan sifat tegangan dan meningkatkan kadar kemerahan sifat tegangan, ketumpatan dan kekerasan setelah 28 hari.

ABSTRACT

Nowadays, there are so many application that can be related to the natural rubber. One of the major application is on tire production. This is because of its properties that will give benefits to the product such as high tensile strength, high hardness and has high deformation state. Unfortunately, when the tire cannot be used anymore in automobile application, there are some alternative way to reuse it either to decompose it through combustion. Recycling of waste tire will reduced the environmental effect such as green house effect, air polution and water polution. However, in recycling process, the waste tire need to be altered in order to make a new product. Cutting, and bending of waste tire are some of altered process. So that, aim of this research are to study about the effect of incooperation starch with natural rubber composites. First stage is the preparation of the samples. It started from modification of starch with silane, then is compounding process by using internal mixer. At last, hot compress is used in order to fabricate the sample. The formulation sample is located at two conditions which is in the room temperature and soil burial condition. The formulation sample was collected after certain days which are 0, 3, 7, 14, and 28 days testing process. Tensile, density and hardness test are being testing in this process. Next, the morphological is being analysed. In this process, several machine is being used which is OM, SEM, XRD, DMTA and FTIR machine. From the results, it can be observed that presence of starch will will lead to decreasing of tensile properties and the decrement of the rate of degradation of the tensile, density and hardness properties after 28 days also has been interpret.

DEDICATION

This thesis research is dedicated specially to my parents Mamy and Babah who always lend me their strength and become good example in taught me to work hard and never give up. Also to the honourable siblings, friends, teachers, lecturers, my supervisor Dr. Noraiham Binti Mohamad, my mentor Pn Mazliah, and everyone who have encouraged and supported me with constant guidance and patience in helping me to finish this report and research completely and successfully.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Generally natural rubber which called as India rubber or *caoutchouc* as initially produced. It consists of polymers of the organic compound isoprene with minor impurities of other organic compounds with addition of water. Malaysia and Indonesia are two of the leading rubber producers. Forms of polyisoprene that are used as natural rubbers are classified as elastomers.

The composites of natural rubber and starch will become important in the future. This is because nowadays, natural rubber composites have extensive used especially in industrial manufacturing. Besides, natural rubber is renewable resources as it is benefits.(Liu, Shao, & Jia, 2008). Natural rubber also mentioned that it is frequently applied in shock and vibration isolators application.This is actually due to its excellent damping properties and it occupies high tensile,high resilience, fatigue resistance, tear properties and its low cost.(Schaefer, 2002).

Ciesielski, (1999) states that natural rubber is the elastomer of choice for the majority of applications that requiring high resilience and level of cycling flexing. However, natural rubber exhibit poor resistance to heat and ozone that makes it not suitable for numerous applications that demands long term resistance to continuous temperatures in excess of 100 C° or exposure to oils and solvents. An interesting about the natural rubber is its combination with sulphur which called vulcanization. Vulcanization rubber has hardness, high tensile

strength and also abrasion resistance. Because of the unique combination of these properties, natural rubber finds its application in the production of various types of products.

Natural rubber properties like mechanical and physical properties make it extremely used and needed in manufacturing industry such as production of tyres, hoses and many more. The highest use of natural rubber is in automobiles and about sixty per cent of all rubber consumed is for automobile tyres and tubes. In tyres, the major percentage of the rubber used is natural rubber. Natural rubber now finds widely use in soil stabilization, in vibration absorption and in road making.

1.2 Problem Statement

Lee et al (2015) mentioned about the beneficial of reusing waste rubber tires. This is because waste rubber tires exhibits low density, high durability, good thermal insulation, high energy absorption and relatively it is low cost. Besides, this method actually can avoid environmental impacts more increased. The greenhouse gas emissions also can be reduced. However, the reuse options for waste tires are significantly affected by the tire's particle size. Some of the recycling applications for tires based on particle size. Some recycling alternatives use whole tires, thus requiring no extensive processing, while other alternatives require that tires be split, punched, or shredded to make new products.

Stanley L. Poole 1998 et al (1998) stated that stockpiling whole tires also poses a significant fire hazard. These fires, some of which may be started intentionally, generate large amounts of heat and smoke and are difficult to extinguish. This is due to the fact that tires basically have more heat energy by weight than does coal (37,600 kJ/kg vs. 27,200 kJ/kg). Furthermore, there is a 75% void space present in a whole waste tire, which cause it difficult to either quench the fire with water or cut off the oxygen supply. Some tire fires have burned continuously for months such as the 9-month Rhinehart tire fire in Winchester, VA. In addition, tire fires cause damage to surrounding areas. As an example, in New Jersey a tire blaze beneath an elevated highway melted the asphalt.

The disposal of whole tires consume a large volume of landfill space. This is because of the tires are relatively not completely compressed and about 75% of the space a tire occupies is void. This void space gives potential sites for collection of gas and rodents harboring. In landfills, waste tires capture hazardous methane gas and "float" upward sometimes shooting to the surface with tremendous force and piercing the landfill cover. The first advantage of the landfilling whole tires is that processing costs are avoided. However, landfills' bad experience with whole scrap tires has led to extremely high tipping fees or total bans on whole tires. Shredding or splitting of tires is becoming increasingly common as part of the disposal process. Shredded tires stored above ground pose less of a hazard than do whole tires.

Shredding eliminates the buoyancy problem and makes tires into a material that can easily be landfilled. Shredding can reduce a tire's volume up to 75%. This volume reduction can also reduce transportation costs because fewer trips are required and maximum hauling weights may be achieved more easily. The main disadvantage of shredding waste tires before landfilling is that an extra processing step is required.

1.3 Objectives

The objectives of this project is :

1. To characterize the tensile and physical properties of starch modified natural rubber composites for the effect of soil biodegradation.
2. To determine the rate of properties reduction of soil degraded starch modified natural rubber composites (days 1 to days 28).
3. To analyse the morphological, compositional and thermal properties of soil degraded starch modified natural rubber composites.

1.4 Scope of Study

The research focuses on characterization and biodegradability of starch modified natural rubber composites. At the first stage, the Tapioca starch was modificated with silane by using ultrasonic machine. At this process,tetrahydrofuran (THF) is used as solvents. Next, process preparation of starch modified natural rubber composites are carried out through melt compounding using Haake rheomix OS internal mixer machine. The temperature of the process was set by 140°C, the time is about 10 minutes and the rotational speed is about 60 rpm. It is mix with some raw material like CBN330, CBS, Glycerol, antioxidant agent, accelerators, vulcanization agent and tetrahydrofuran (THF). The next process is fabrication of curing of the starch modified natural rubber composites. This process are using hot press machine with temperature 140°C for about 10 minutes. For the second stage, physical and mechanical test process was carried. For this process, there are two formulation sample which is compound with starch and without starch. The formulation sample is located at two condition which is in the room temperature and soil burial. For the room temperature, the sample was located at room in the lab material in block B faculty engineering manufacturing University Technical Malaysia Melaka. At soil burial, samples are planted at one bucket of soil. All sample for soil burial condition will be planted there. The formulation sample is collected after certain day which is 0, 3, 7, 14, and 28 days testing process. Tensile, density and hardness test are being testing in this process. Next, the morphological is being analysed. In this process, several machine is being used which is SEM, XRD, and FTIR machine.

1.5 Thesis Overview

This report is divided into five chapters that describe the analytical and experimental research performed. For the chapter one, it is more to an introduction to the study which is research background, problem statement, objectives, scope and the thesis overview. Next, chapter two shows a detailed literature review of relevant theory related to starch modified and natural rubber composites are discussed. Previous investigations on the issues and current studies of starch modified on natural rubber composites effects are proposed as well. The important elements include the materials, surface modification, processing involved and also

related experimental testing methods. For the chapter three, this chapter obtained the methodology used for overall research work, raw materials characterization, samples preparation and analysis and testing process. In the chapter four, the results of the characterization, analysis and mechanical measurement of various engineering properties on starch modified natural rubber composites are presented in depth. The analysis of biodegradability of the composites also showed. Finally, chapter five shows summerization of major findings and conclusion of studies. There are also future project that recommended.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews about the existing studies on starch and natural rubber. It consists of its physical properties, structures of the starch and natural rubber and its mechanical properties such as tensile strength, temperature and many more. There are studies of reinforcement/filler material specifically carbon black. Finally, it covers the concept of biodegradability based on some references of journals.

2.2 Natural Rubber Composites

2.2.1 Matrix of natural rubber composites

Generally, natural rubber is found in the latex which comes from the rubber tree. According to Vudjung et al, (2014), natural rubber is a hydrophobic polymer that has high elasticity. But, its structure has unsaturated double bonds which it can be decomposed by environmental agent such as heat, UV light, oxygen and ozone.

Natural rubber (NR) is a high molecular weight polymer that is originally obtained from milky suspension in the sap of certain plants. It is also one of the most material that used to fabricated into rubber products (Ciesielski, 1999). Russian dandelion rubber and Mexican shrubs is a example of types of natural rubber that have been commercially exploited.

However, only Hevea Brasiliensis tree currently planted on a large scale found in Southeast Asia and Africa (Rippel and Galembeck, 2009). Figure 2.1 shows the chemical structures of NR from Hevea Brasiliensis tree.

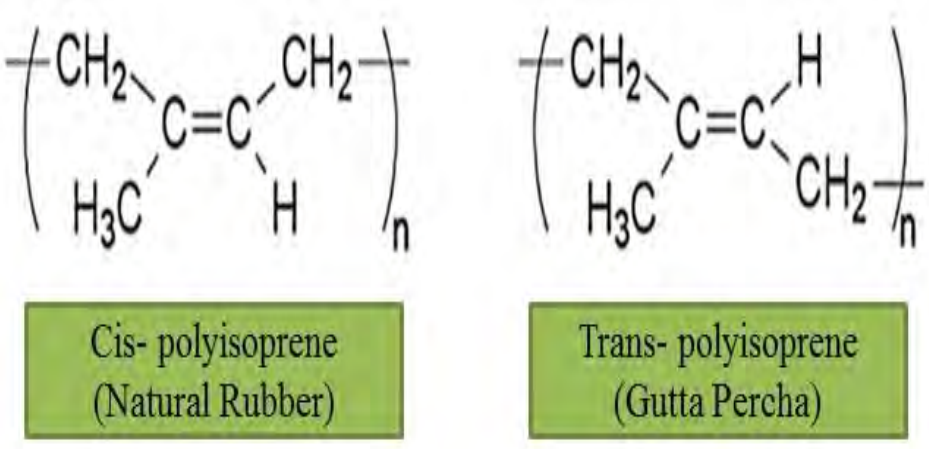

Figure 2.1: Formulation of chemical natural rubber (Devaux and Demoustier, 2008)

Natural rubber will be hardens below 0°C. Meanwhile, softens and weakens state is above 80°C. After that,, natural rubber will losing its strength and becoming tacky. (Ciesielski, 1999). Between these temperatures, it actually can flow under stress and permanent deformation will occurs under prolonged strain. These disadvantages properties can be reduced using alternative way which is vulcanization process. In this process, the reactivity of the double bonds impart to the molecule and it is utilized to make it react with added material and the cross links between the chains will be formed. The cross linking will increases the useful temperature range of the rubber and hardens the rubber so that it becomes more stronger and does not creep. Besides, the natural rubber also will returns to its original shape on release of stress (Brinke, 2002).

2.2.2 Reinforcement in natural rubber composites

2.2.2.1 Carbon Black

Carbon black basically has a several name such as acetylene black, furnace black, channel black, lamp black or thermal black.(encyclopaedia Wikipedia). This material was

produced by incomplete combustion process of heavy petroleum products. Ethylene cracking tar, fluid catalytic cracking tar (FCC), coal tar, and a small amount from vegetable oil are the example for heavy petroleum products.

Yantaboot & Amornsakchai, (2017) stated that the presence of certain types of filler usually will affect some physical properties such as strength, modulus, tear resistance and abrasion. He also said that carbon black and silica is example of reinforcement filler agents. Tires hoses, seals and belts are example carbon black products.

There are also result of the experiment based on the article which is in figure 3 and figure 4. In his studies, he has use some material in order to find weather reinforcement filler agent will affect the tensile strength or not. He has use some material composites such as natural rubber/pineapple leaf fibre (NR/PALF) and natural rubber/pineapple leaf-carbon black (NR/PALF) hybrid composites.

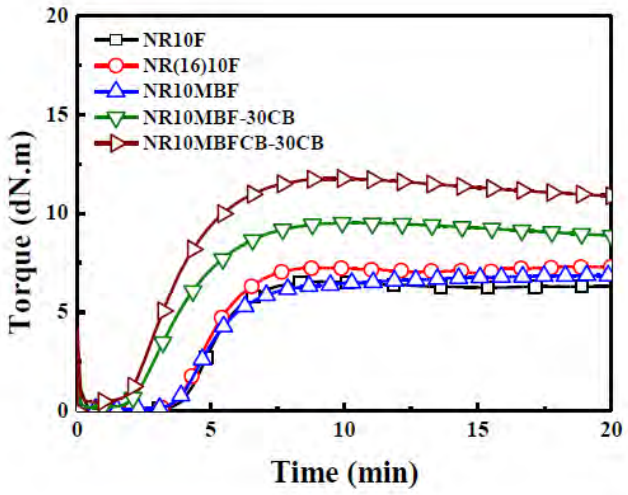

Figure 2.2: Cure curves of different composite compounds.

Figure 2.3(a) displays stress-train curves obtained during the tear test. Tear strength calculated from the curves along with composite hardness are shown in figure 2.3 (b) .It can be seen that addition of PALF and carbon black by different methods barely affects the tear strength of the composites. As results, addition of carbon black significantly increases the tear strength. But, all composites shows extremely similar hardness and there is no effect of carbon black is seen.