Faculty of Mechanical and Manufacturing Engineering Technology

TENSILE STUDY OF CHLOROPRENE RUBBER WITH COAL ASH AS GREEN FILLER REINFORCEMENT

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This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours

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DECLARATION

I hereby, declared this report entitled “Tensile Study or Chloroprene with Coal Ash as Green Filler Reinforcement” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours. The member of the supervisory is as follow:

……

(Mr Hairul Effendy Bin AB Maulod)

ABSTRAK

Getah kloroprene adalah salah satu sintetik yang tahan minyak pertama. Ia boleh dianggap sebagai getah kegunaan umum yang cemerlang dengan kestabilan kualiti fizikal dan kimia yang berkualiti tinggi. Pengisi boleh juga digunakan menggunakan ubahsuai sifat fizikal berkenaan dengan tidak tervulkan atau tervulkan. Projek ini memberi tumpuan kepada kajian tegangan getah kloroprena dengan abu arang batu sebagai tetulang pengisi hijau. Abu arang batu digunakan sebagai pengisi untuk getah kloroprene sebagai bahan matriks utama dengan menggunakan formulasi berasaskan kesusasteraan untuk mencari perbaikan pada sifat fizikal dan mekanik mereka. Projek ini dijalankan untuk menentukan formulasi terbaik kloroprena dengan sebatian abu arang batu. Selain itu, untuk mengkaji sifat mekanikal seperti kekuatan tegangan dan kekerasan bahan. Untuk menghasilkan produk, sampel sebatian bahan telah dibuat sebelum menjalani pelbagai ujian. Untuk menghasilkan sebatian bahan, komposisi perbezaan telah dikaji dan proses pencampuran dilakukan menggunakan mixer dalaman. Selepas itu, komposisi itu dibuat menjadi lembaran nipis menggunakan mesin tekanan panas dengan keadaan tertentu. Kemudian, sampel bahan dipotong mengikut ASTM bagi setiap ujian. Projek ini memberi tumpuan kepada ujian mekanikal seperti ujian tegangan dan ujian kekerasan. Ujian fizikal pada sampel juga menjalani ujian ketumpatan. Analisis morfologi sampel telah dibuat menggunakan pengimbasan mikroskop elektron. Peningkatan kandungan abu arang batu telah meningkatkan kekuatan dan kesan tegangan pada tingkah laku ujian mekanikal berbanding kloroprene tulen. Secara keseluruhannya, semua objektif penyelidikan yang telah disenaraikan berjaya dicapai dari kajian awal ini.

ABSTRACT

Chloroprene rubber is one of the first oil resistant synthetic rubbers. It may be considered as an excellent general purpose rubber with a high-quality stability of physical and chemical properties. Fillers may additionally lie used according to modify the physical properties concerning either unvulcanized or vulcanized rubbers. This project focuses on tensile study of chloroprene rubber with coal ash as green filler reinforcement. Coal Ash (CA) is used as filler for chloroprene rubber (CR) as a primary matrix material by using literature based formulation in search of improvement on their physical and mechanical properties. This project was carried out to determine the best formulation of chloroprene with coal ash compound. Besides, to study the mechanical properties such as tensile strength and hardness of material. In order to produce the product, the samples of the material compound have been made before undergo with various testing. To produce the material compound the difference compositions have been study and the mixing process was done using internal mixer. After that, the composition was fabricate into thin sheets using hot press machine with specific condition. Then, material sample was cut according to ASTM of each testing. This project focused on mechanical testing such as tensile test and hardness test. Physical testing on the sample also undergo density test. The morphological analysis of the sample has been made using scanning electron microscopy. The increasing of coal ash content had significantly increase tensile strength and effect to the mechanical testing behaviour compared to pure chloroprene. In overall, all the listed research objectives were successfully achieved from this preliminary research.

DEDICATION

This report is dedicated to Mr. Hairul Effendy Bin Ab. Maulod for without his early inspiration, coaching and enthusiasm, none of this would have happened. This dedication is especially dedicated to my parents. To my father, Kamal Bin Mat for his ongoing love and support, he also taught me to trust in Allah and believe in hard work and to my mother who could not see this final report completed. I also dedicate this report to my family who always support me with their unconditional love that motivates me to set a higher target in completing this final year project. This dedication is also to my lovely friends that have provided me with a cherished love shield and always surround me and never lets any sadness enter inside.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AMD	-	acid mine drainage
ASTM	-	American Standard Testing Method
ATH	-	Aluminum Trihydrate
BT	-	Billion Tonnes
CA	-	Coal Ash
Cl	-	Chlorine
CR	-	Chloroprene
CR%	-	Per Hundred Chloroprene Percentage
EPDM	-	Ethylene-Propylene Diene
EVCL	-	Ethylene-vinyl Chloride
FA	-	Fly Ash
FRP	-	fiber reinforced polymer
MS	-	Marble Sludge
MSW	-	Municipal Solid Waste
MSWI	-	Municipal Solid Waste Incineration
MT	-	Million Tonnes
Mton	-	Metric Ton
N	-	Newton
NBR	-	Acrylonitrilebutadiene

OM	-	Optical Microscope
phr	-	Per Hundred Rubber
PVA	-	polyvinyl alcohol
PVC	-	Polyvinyl Chloride
SBR	-	Styrene-butadiene
SEM	-	Scanning Electron Microscopy
Si-69	-	Silane
SLS	-	sodium lauryl sulphate
TMTD	-	Tetraethyl ThiuramDisulphate
USSR	-	Union of Soviet Socialist Republics
UTM	-	Universal Tensile Machine
UTS	-	Ultimate Tensile Strength
wt%	-	Weight Percentage

CHAPTER 1

INTRODUCTION

This chapter will explain the overview of the study and the main purpose of this study. The chapter is generally classified into background of study, problem statement, objectives and the scope about the study.

1.1 Background of Study

Technology innovation is very essential in the rubber industry appropriate to the rapid development of new materials and the strengthened global environmental regulations. Rubbers are elastomers, either of natural or synthetic. Elastomers are extensible polymers with typically some viscoelastic nature. During World War II synthetic elastomers have been raised due to the limited supply of natural rubber in Asia. From ancient times to the present, elastomers have been constantly advanced and applied in many merchandise (Limpanichpakdee, 2017).

Some of the products that are made from rubbers are essential in applications such as; potential application areas include mining, power generation, agriculture, transportation paper industries and the rubber insulation of cables and wires Rubbers also can be used for various equipment of livestock such as harness, collars, horse-shoes, rubber saddles, milking machine

hoses and so on. Their use in footwear industry and in rubber based textile goods are some of the important applications. Various latex rubber articles are also used in medicine and surgery, such as draw sheets, gloves, finger stalls, teats, and hot water bottles. Rubber from used tyres and tubes is used to make shoes, bushings, washers, gaskets, wheels, containers, and a wide range of products for domestic, commercial and industrial use.

Rubbers are generally acknowledged as strategic materials, can be tailored by adding fillers to meet the demands in versatile industry applications (Mao, et al., 2013). Filler materials are normally the inert materials which are used in composite materials to minimize material costs, to enhance mechanical properties to some extent and in some cases to improve processability. The mechanical properties of fly ash as filler is filled chloroprene rubber are the focus of this project. Fly ash is a coal combustion by-product, which accumulates appropriate to electrostatic precipitation of the flue gases in thermal power plant. When coal is burnt in thermal power plant the ash is transport forward in flue gases as fused particles, which coagulates as like a spherical particle. Most of these spherical particles have a gas bubble at the center. The ingredients of fly ash particles as obtained from coal in Britain are silica (59.5%), Alumina (20.3%), FeO /Fe2O3 (6.5%), remaining being FeO, MgO and unburnt coal and many others (Chawla, 2010).

Million tonnes of fly ash is being generated annually in India, with 65 000 acres of land being occupied by ash ponds (Nawaz, 2013). This kind of a large amount poses a challenging problem, in the form of land use, health risks, and environmental hazards. Both in disposal, as well as in use, utmost care needs to be addressed, in order to safeguard the interest of human life, wildlife, and surroundings. The form, size, quantity fraction, and specific surface area of the additional particles as in the polymer have been found to affect the very high mechanical properties of the composites. Coal ash contains fine silica and alumina with

small quantity of calcium and magnesium oxides. Coal ash forms at temperature in the range of 920 to 1200 ºC and collected as precipitator ash in the boiler used for generating steam to produce electricity in the thermal power plant.

Coal ash has a density in the range of 2.0 to 2.5 g/cm3. It may increase various properties of selected matrix materials, which include stiffness, strength, and wear resistance by its inclusion in small quantity. Tensile strength and composite modulus filled with coal ash and rubber increase with increasing of filler contents but impact strength and elongation at break are found can be reduced (Shyamkumar Shah, 2014).

In the present study, coal ash was used as a reinforcing filler in chloroprene rubber compounds. The coupling agent, silane was used to improve the interfacial interaction between coal ash and chloroprene rubber. The concentration of coal ash on the performance of chloroprene rubber, such as the tensile strength and hardness was investigated.

1.2 Problem Statement

Expanding industrial activities demand materials that are expected to satisfy increasing requirements of strength, modulus, heat distortion temperature, low coefficient of expansion, and reduction in cost. This demand has provided a wide scope for the use of polymeric composite materials. The strength of the composite can be improved by the use of filler. Fillers can be added to latex to reduce the cost of rubber articles, to avoid spreading leaking mixture through the fabric, to increase the viscosity of the compound or to alter the properties of the rubber.

Rubber reinforcement by adding filler is associated with chemical and physical interactions between rubber and filler that commonly depend on the physicochemical

character of the filler surface and the chemical nature of the rubber, despite the fact that the correct mechanism of the reinforcement is completely incomprehensible. More than 90% of chloroprene produced annually is used to make polychloroprene, which constitutes the well-known DuPont product Neoprene. This solvent-resistant elastomer, made by free radical initiated polymerization of chloroprene, is used to make many automobile rubber products, example of tires, hoses, and belts. Polychloroprene is formulated into adhesives and latex emulsions for dip covered goods. Other products made from polychloroprene are rubber personal protection garments such as gloves, footwear, and wetsuits. Polychloroprene also used in conveyor and transmission belts, sealing materials, and electrical insulating materials.

As previous study, the ash residues are wastes of coal-fired power plants, and they are produced in a plant boiler outlet; including fly ash (FA) and bottom ash. It has been estimated that the quantity of ash residue produced in Thailand in 2002 were 3 million tons, of which only 1.8 million tons were used for concrete production applications (N. Sombatsompop, 2004). In this project, we aim to utilize of CA as potential filler in rubber materials as it contains almost 50% silica by weight of the total FA and because the cost is relatively low (ca. 50 times less expensive than commercial silica based on the purchase cost in Thailand). FA has been used as filler mostly in thermosetting materials, such as unsaturated polyester. The increasing quantity of FA reduced the tensile strengths and impact of polyester composites.

This research aimed to seek the optimum FA quantity as to be added into the CR compounds. Therefore, a wide range of properties of the FA-filled rubber compounds were studied, inclusive of crosslink density, tensile modulus, and hardness.

1.3 Objectives

The objective of the project is to:-

i. To characterize formulation of chloroprene rubber with coal ash.
ii. To prepare the compound of chloroprene rubber with coal ash.
iii. To study the tensile properties of chloroprene rubber with coal ash as green filler reinforcement at different loading percentage

1.4 Scope

The study on this topic can be benefit for certain circumstances. This research is "Tensile Study of Chloroprene Rubber with Coal Ash as Green Filler Reinforcement" through the mixing material using internal mixer and tests their properties. The scopes of this study is focusing more on tensile properties of chloroprene and coal ash through the melt compounding method and its properties effect and analyzed by using the Universal Tensile Machine (UTM) and Scanning Electron Microscopy (SEM). The findings will be further supported by the analysis of Optical Microscope.

1.5 Organization of Project Study

This project study is divided into four chapters that discuss the analytical and experimental project performed. This dissertation shows the coal ash used as a reinforcement. The effects of green reinforcement of coal ash have been studied, in search of improvements on their physical and mechanical properties. The organization of this research study is as

follows. This dissertation has been organized into five chapters. The first chapter begins with an introduction about the project study and also brief about objectives, problem statement, significant of study and the thesis overview.

Chapter two begins on the literature background of this study. It discusses on the history of composite, types of composites and matrices. The important element that included in this chapter is about the mechanical properties and used of coal ash, chloroprene and the mechanical behavior of polymer composite.

Chapter three provides details explanations on the methodology used for overall project work, raw materials, procedure property analysis that had been done. In this chapter four, instead of investigation of mechanical behavior of chloroprene and coal ash composite, also want to understand the relationship of the compound with different composition of coal ash. The final chapter (Chapter 5) concludes the overall results obtained from this research. In this chapter, it explains either the objectives of this study are achieved or not. The recommendation for future project also has been included in this Chapter 5.

CHAPTER 2

LITERATURE REVIEW

In this chapter explain about all findings obtained from many literature reviews, which may come from the internet online, journals, article and books about the topic that is related to this final year project study. This chapter also explains about the overview of the elastomer from chloroprene rubber and composites from coal ash at green filler loading. The success of a design and material testing also depends on the creativity of designers and the use of appropriate technology to meet the needs of effective and functional. The design and study is ongoing process that involved creative problem solving is known as a literature.

In the production this project, all theory and information of material substance used, production and testing in relation this project has been described to achieve objective of the project.

2.1 Chloroprene

Synthetic rubber is made of raw material derived from petroleum, coal, oil, natural gas, and acetylene. At the present time over 75% of the rubber used in United States is synthetic, while on the world basis about 65% of the rubber is synthetic. The various types of synthetic rubber are styrene-butadiene rubber (SBR), acrylonitrilebutadiene copolymers (NBR latex),

ethylene-vinyl chloride copolymers (EVCL), polybutadiene, polychloroprene (neoprene) (Ali Shah, Hasan, Shah, Kanwal, & Zeb, 2013).

The industrial application of CR was started in 1932. CR is available in both dry and latex forms. Dry grades of polychloroprene rubber are typically utilized in industrial and automobile rubber items, including hoses and belts. Latex grades of polychloroprene rubber are utilized in waterborne adhesives and dipped items, including gloves and consistent speed joint boots. Numerous studies were mentioned at the exquisite assets improvement of CR nanocomposites within the presence of various kinds of nano filler (Debnath, 2015).

Polychloroprene is an extremely versatile synthetic rubber possessing similar chemical structure to natural rubber and therefore, inheriting the excellent dynamic and mechanical properties along with an added advantage of improved oil and ozone resistance due to the presence of highly electronegative –Cl (chlorine group) in the backbone of the rubber structure. This unique combination of properties has enable polychloroprene to find applications in thousands of diverse environments. Polychloroprene exhibits good resistance to degradation from the sun, ozone and weather, it performs well in contact with oil and many chemicals, and resists burning. It has outstanding resistance to damage caused by flexing and twisting (Manohar, et al., 2017).

Chloroprene rubber also called Neoprene is one of the first oil resistant synthetic rubbers. It may be considered as an excellent general purpose rubber with a high-quality stability of physical and chemical houses. Further, it has higher chemical, oil, ozone, and heat resistance than herbal rubber. Chloroprene rubber is extensively used because of its wide range of beneficial properties and reasonable price. Common applications consist of belting, coated fabric, calve jackets, seals, and gaiters (Beomkeun Kim, 2012).

Chloroprene is has many properties likes, stretchable, waterproof, chemical-resistant and abrasion-resistant properties. These properties make the rubber ideal for use in products such as wet suits orthopaedic devices, and sports gloves (Ramzy, Hagvall, Pei, Samuelsson, & Nilsson, 2015).

Chloroprene rubbers (CR) are homopolymers. The polymer chains have an almost entirely trans-1- 4-configuration. Because of this high degree of stereoregularity, they are able to crystallize on stretching (Salmah, Azra, Yusrina, & Ismail, 2015). As shown in Figure 2.1. Chloroprene monomer is 2-chlorobutadiene, i.e., butadiene with a chlorine atom replacing on of the hydrogen. Since the polymer comprise almost entire of trans-1,4 units, as shown (Figure 2.1), the chains are sufficiently ordinary within structure according to crystallize on stretching. Hence chloroprene reveals high tighten tensile then is used of the pure tighten form within much applications.

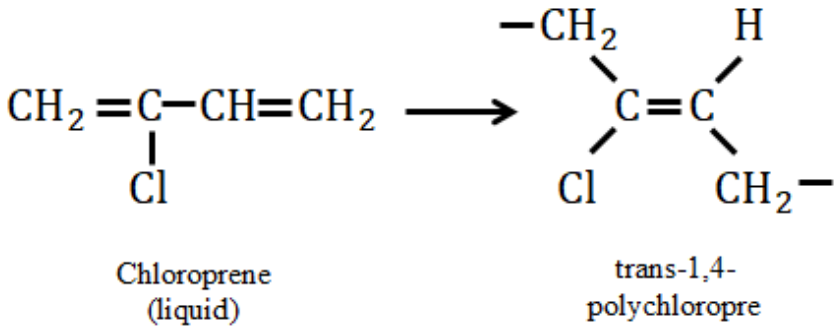

Figure 2. 1: Neoprene is essentially a polychloroprene (Morton, 2013)

The vulcanization of neoprene is a bit different from the elastomers considered so far. It is not same like the others; it is not vulcanized by means of sulphur. In the contrary, use is made from fact that the chlorine atoms on the chain can react slightly with active metal oxides.