UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE STUDY OF NATURAL RUBBER/POLYETHYLENE POLYMER MIXING METHOD

Thesis submitted in accordance with the requirements of the
University Technical Malaysia Melaka (UTeM) for the Degree of
Bachelor of Engineering (Honours) Manufacturing (Material Engineering)

By

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DECLARATION

I hereby declare that this report entitled **"THE STUDY OF NR/PE POLYMER MIXING METHOD"** is the result of my own research except as cited in the references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (*Material Engineering*). The members of the supervisory committee are as follow:

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ABSTRACT

This research is focused on examining and characterizing the properties of combination of elastomer which is natural rubber with thermoplastic which is polyethylene. Improvements in strength of polyethylene (PE) can be sought by melt blending with natural rubbers (NR). In this study, PE is blended with two types of different NR which is indoor and outdoor storage. In this research, it is studying about the properties with two type of polymer which is elastomer and thermoplastic when they are blending together. The purpose of this research is to improve the thermoplastic elastomer based on rubber-plastic blends and also to determine their mechanical properties with different ratio mixing between of them. The ratio percentage blended between natural rubber and polyethylene that are focused in this work which is 10%, 20% and 30% of natural rubber. Each percentage of this, were examining their mechanical properties with two types of testing which are flexure test and tensile test. In the end of this research, NR indoor is identified as a good NR that can blended properly with polyethylene than NR outdoor based on the result from mechanical testing.

ABSTRAK

Kajian ini adalah fokus kepada penilaian dan ciri-ciri sifat yang ada pada penggabungan elastomer iaitu getah natural dengan plastic haba iaitu polietilena. Pembaikan atau peningkatan dalam kekuatan yang ada pada “polyethylene” boleh diperoleh melalui campuran cair bersama dengan getah natural. Dalam kajian ini juga, polietilena dicampurkan dengan dua jenis getah natural yang berlainan keadaan iaitu getah natural yang diletakkan didalam rumah (terlindung dari cahaya matahari) dan getah natural yang diletakkan diluar rumah (terdedah kepada cahaya matahari, hujan dan sebagainya). Didalam kajian ini, sifat-sifat yang terhasil diantara elastomer dan plastik haba kesan daripada gabungan kedua-duanya telah dikaji. Tujuan kajian ini dilakukan adalah untuk memperbaiki atau meningkatkan sifat yang ada pada “plastik haba elastomer” berdasarkan campuran yang dilakukan dan juga untuk menentukan sifat-sifat mekanikal mengikut nisbah campuran yang berlainan. Manakala peratus nisbah campuran diantara getah natural dan polietilena dalam kajian ini hanya tertumpu kepada 10%, 20% dan 30% dari getah natural. Setiap peratusan ini, dinilai kekuatan mekanikalnya melalui dua jenis ujian iaitu ujian tegangan dan ujian pelenturan. Di akhir kajian ini, keputusan yang dicapai adalah getah yang diletakkan didalam rumah adalah lebih bagus dan elok dalam pencampuran bersama dengan polietilena berbanding dengan getah yang diletakkan diluar rumah.

DEDICATION

I want to dedicate this research project to my father, Osman bin Husin; who everlastingly stays in my heart, my mother, Fatimah binti Hj.Isa, my brothers, Arifin Osman, Muhd Al-Amin Osman and Fauzi Osman, my sisters, Mastura Osman and other members of my family for their continual support, prayers, understanding and most importantly patience during my time in graduate school.

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During several steps of one's life, the road seems uphill and full with challenges and obstacles. While we are traveling along that road, countless times we sigh and then ask ourselves what is the reason of going through. It is indubitably true about the part of my life here, in Malacca. Still and all, this journey is enjoyable and memorable because of helps and kindness from a special group of individuals that I would like to mention as follows. Not only I have gained much knowledgement about polymers here, but also I have learned to work and to discipline myself in order to achieve certain important goals in life.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

TPE	-	Thermoplastic elastomer
NR	-	Natural rubber
PE	-	Polyethylene
HA	-	High ammonia latex
LATZ	-	Low ammonia latex
IR	-	Polyisoprene
IIR	-	Copolymer of isobutylene and isoprene
CIIR	-	Chloro Butyl Rubber
BIIR	-	Brono Butyl Rubber
BR	-	Polybutadiene
SBR	-	Styrene butadiene rubber
NBR	-	buna N.rubber
HNBR	-	Hydrated Nitrile Rubbers
CR	-	Chloroprene Rubber
EPM	-	ethylene propylene rubber
ECO	-	Epichloroyhdrin rubber
ACM, ABR	-	Polyacrylic rubber
SI	-	Silicone rubber
FVMQ	-	Fluorosilicone rubber
FPM	-	Fluoroelastomers
FFRM	-	Perfluoroelastomers
PEBA	-	Polyether Block Amides
FEPM	-	Tetrafluoro ethylene
CSM	-	Chlorosulfonated polyethylene
EVA	-	Ethylene vinylacetate

TPV	-	Thermoplastic vulcanizates
NRL	-	Natural rubber latex
EB	-	Extensibility
NH_3	-	Ammonia
MST	-	Mechanical stability time
VFA	-	Volatile fatty acid number
ISO	-	International Standard Operation
H	-	Hydrogen
C	-	Carbon
LDPE	-	Low-density polyethylene
HDPE	-	High-density polyethylene
PVC	-	Polyvinyl chloride
W	-	Width
L	-	Length
G	-	Gage length
R	-	Radius
D	-	Distance
ε	-	Strain
σ	-	Stress
E	-	Modulus of elasticity
EL	-	Elongation
σ_b	-	Flexure strength
LNR	-	Liquid natural rubber

CHAPTER 1

INTRODUCTION

1.1 Introduction

In combining together different materials to form a mixture, there are two major concerns. One of these is to produce a homogeneous mixture on a global level. The achievement of compositional homogeneity in a mixing process is said to occur through distributive mixing. The second concern is to produce as fine a dispersion of the ingredients as possible (James L.White, 2001). For rubber-plastic blends, they have been commercialized as thermoplastic elastomers (TPEs). The mechanical and rheological properties of these blends depend not only on those of constituent polymers but also on the morphologies of blends. In order to improve the properties of thermoplastic elastomers based on rubber-plastic blends, one should understand the relationships between morphology, processing and properties of these materials.

Natural rubber (NR) and polyethylene (PE) are very important industrial elastomer and thermoplastic, respectively which both are widely used in different industries. Thermoplastic properties can be imparted into natural rubber (NR) via its melt blending with any compatible thermoplastic such as polyethylene (PE). Such blend is generally termed thermoplastic natural rubber and by the physical characteristics exhibit, is categorized as an elastomer lying between rubbers and plastics (Azizan Ahmad, 2005). This project is study to obtain the mechanical properties of blends of natural rubber (NR) with polyethylene (PE). This enables a green material to enter many markets from which it had previously been precluded for several decades, such as automotive weatherstrip. Structurally, polyethylene is expected to be more readily compatible with natural rubber when they are blended together (Azizan Ahmad, 2005).

Thermoplastic elastomers (TPEs) have become very important during last few decades. Thermoplastic elastomeric compositions based on rubber-plastic blends are becoming increasingly significant because of their combination of elastomeric properties and ease of thermoplastic processing to give low-cost end-use products. In order to improve the properties of thermoplastic elastomers based on rubber-plastic blends, or to find new rubber-thermoplastic combination to form thermoplastic elastomers, one should understand the relationships between morphology, processing and properties of these materials. Thermoplastic natural rubber is being based on blends of NR with thermoplastic which is polyethylene (PE). It can blend with different ratios and a wide range of properties can be obtained.

In this study, natural rubber is used as one types of elastomer. It is because hevea-based natural rubber (NR) is one of the most interesting rubbers, because of its unique properties in numerous respects and also because of its low price in some tropical countries, especially in Southeast Asia. Natural rubber latex is stabilized by proteins layer and fatty acid surfactants/lipids on the surface of the rubber particles which carry a negative charge. Actually, latex concentrate is divide to two categories which is high-ammonia latex (HA), preserved with not < 0.61% ammonia and low ammonia latex (LATZ), preserved with not <0.31% ammonia.

1.2 Problem Statement

Natural rubber (NR) is one of the most interesting rubbers because of its unique properties in numerous respects. Because of that, NR is blended with another type of polymer in order to improve their properties. But, the problem is, in what condition or type of natural rubber is a good quality before blend it with another material. So, in this study it must to be investigating for getting the good and best quality of properties natural rubber between indoor and outdoor storage. It is because, the properties of natural rubber will changes and their quality will decrease time by time. Besides that, the advantages and disadvantages relationship between natural rubbers blend with polyethylene also must to be investigate to find a new rubber-thermoplastic combinations in order to form a good product in future.

1.3 Objectives

i) To compared their properties between two different condition of natural rubber which is NR in outdoor storage and NR in indoor storage.

ii) To determined the stabilization of the natural rubber with different condition.

iii) To study about the combination of natural rubber with thermoplastic (PE).

1.4 Scope of Project

The blending of polymers provides a powerful route for obtaining materials with improved property performance. The scope of this project is to produce high quality blends of natural rubber with thermoplastic which is polyethylene at different condition of natural rubber such like indoor and outdoor storage. From this research, the type of suitable condition of natural rubber blended with polyethylene is defined. Besides that, their mechanical properties with two different ways of testing which is flexure test, and tensile test are obtained. The high quality blends and their mechanical strength is depending on the ratio percentage between natural rubber and polyethylene. In this research, it's only concentrate to 10%, 20%, and 30% of natural rubber that blended with polyethylene.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is describing the topic of elastomer and thermoplastic, how natural rubber or elastomer can blend with thermoplastic and answers the following questions:

a) What is elastomer?
b) What is thermoplastic?
c) What is polymer blends?

2.2 Elastomer

The term *elastomer* is often used interchangeably with the term rubber, and is preferred when referring to vulcanisates. Elastomer comes from two terms, *elastic* (describing the ability of a material to return to its original shape when a load is removed) and *mer* (from polymer, in which *poly* means *many* and *mer* means *parts*). Each link of the chain is the "-mer" or basic unit that is usually made of carbon, hydrogen, oxygen and/or silicon. To make the chain, many links or "-mers" are hooked or polymerized together. They are amorphous polymers existing above their glass transition temperature, so that considerable segmental motion is possible. At ambient temperatures rubbers are thus relatively soft (E~3MPa) and deformable. Their primary uses are for seals, adhesives and molded flexible parts. .(R.Chandra, S.Mishra, 1995)

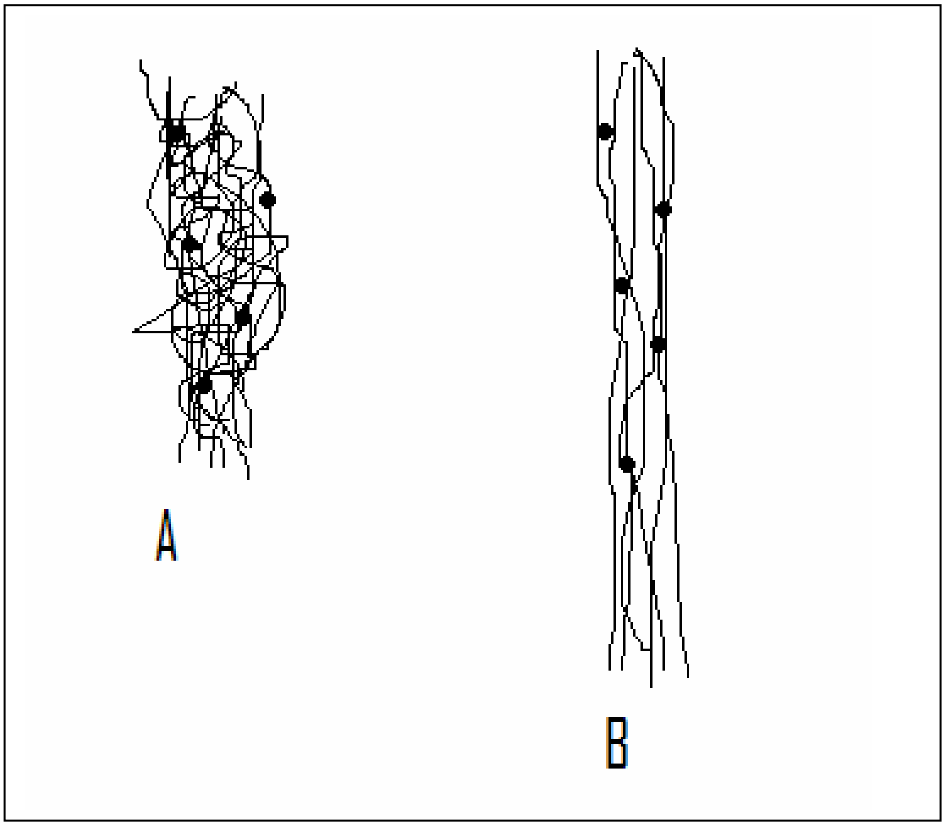

Figure 2.1: Schematic drawing of an unstressed polymer. The dots represent cross-links. B is the same polymer under stress. When the stress is removed, it will return to the A configuration.

Elastomers are usually thermosets (requiring vulcanization) but may also be thermoplastic (see thermoplastic elastomer). The long polymer chains cross-link during curing. The molecular structure of elastomer can be imagined as a 'spaghetti and meatball' structure, with the meatballs signifying cross-links. The elasticity is derived from the ability of the long chains to reconfigure themselves to distribute an applied stress. The covalent cross-linkages ensure that the elastomer will return to its original configuration when the stress is removed. As a result of this extreme flexibility, elastomer can reversibly extend from 5-700%, depending on the specific material. Without the cross-linkages or with short, uneasily reconfigured chains, the applied stress would result in a permanent deformation. .(R.Chandra, S.Mishra, 1995)

2.2.1 Examples of elastomer

2.2.1.1 Unsaturated rubbers that can be cured by sulfur vulcanization:

a) Natural Rubber (NR)
b) Polyisoprene (IR)

   i. Butyl rubber (copolymer of isobutylene and isoprene, IIR)
   ii. Halogenated butyl rubbers (Chloro Butyl Rubber: CIIR; Bromo Butyl Rubber: BIIR)

c) Polybutadiene (BR)

   i. Styrene-butadiene Rubber (copolymer of polystyrene and polybutadiene, SBR)
   ii. Nitrile Rubber (copolymer of polybutadiene and acrylonitrile, NBR), also called buna N rubbers
   iii. Hydrated Nitrile Rubbers (HNBR) Therban® and Zetpol

d) Chloroprene Rubber (CR), polychloroprene, Neoprene, Baypren etc.

2.2.1.2 Saturated Rubbers that cannot be cured by sulfur vulcanization:

i. EPM (**ethylene propylene rubber**, a copolymer faeces of polyethylene and polypropylene) and EPDM rubber (**ethylene propylene diene rubber**, a terpolymer of polyethylene, polypropylene and a diene-component)
ii. Epichlorohydrin rubber (ECO)
iii. Polyacrylic rubber (ACM, ABR)
iv. Silicone rubber (SI)
v. Fluorosilicone Rubber (FVMQ)
vi. Fluoroelastomers (FKM, FPM) Viton, Tecnoflon, Fluorel, Aflas and Dai-El

vii. Perfluoroelastomers (FFKM)Kalrez
viii. Polyether Block Amides (PEBA)
ix. Tetrafluoro ethylene/propylene rubbers (FEPM)
x. Chlorosulfonated Polyethylene (CSM), (Hypalon)
xi. Ethylene-vinyl acetate (EVA)

2.2.1.3 Various other types of elastomers:

i. Thermoplastic Elastomers (TPE), for example Hytrel, etc.
ii. Thermoplastic Vulcanizates (TPV), for example Santoprene TPV
iii. Polyurethane rubber
iv. Resilin, Elastin
v. Polysulfide Rubber

2.2.2 Elastomer Properties Chart

Physical properties	Natural Rubber NR	Styrene Butadiene SBR	Neoprene CR	Urethane
Polymer Spec. Gravity	0.93	0.93	1.23	1.05
Durometer Range	30-100	30-100	15-95	20-100
Tensile Strength, PSI	4000+	3000	3000	To 8000
Elongation, %	To 700	500	To 800	To 650
Tear Resistance	Excels	Good	Good	Excels
Weather Resistance	Fair	Fair	Excels	Excels
Solvent Resistance: Aliphatic Hydrocarbon	Poor	Poor	Good	Excels
Solvent Resistance: Aromatic Hydrocarbons	Poor	Poor	Poor	Fair
Brittle Point ^{o}F	-80	-80	-50	-60
Stiffening Point ^{o}F (avg)	-40	-35	-10	-20
Compression Set	Good	Good	Fair	Excels
Abrasion Resistance	Excels	Excels	Good	Excels
Flex Resistance	Excels	Good	Good	Good

2.2.3 Natural Rubber

Natural rubber (NR) is used as a type of elastomer to blend with a thermoplastic which is polyethylene (PE). So, the background of NR and their properties must be investigated. Actually rubber is a group of industrial material like metals, fibers, wood, plastics, glass etc. on which the world of modern technology depends. The world consumption of rubber is in the order of about 16 million tons per annum and has been increasing in recent years at the rate of about 4% per annum. Out of this about $1/3^{rd}$ is man made synthetic rubber mainly produced from petroleum fractions.

The unique and versatile properties of rubber have made it highly indispensable for the modern way of life. The mobility or speed of movement of the modern world mainly dependent on rubber; in the form of bicycle tyres to highly sophisticated pneumatic tyres for motor vehicles and aeroplanes etc. Its importance as strategic material due to its valuable contribution in defence application is well recognized. The distinguishing of rubber is its resilience and elasticity. In many of its modern applications rubber is not used alone but reinforced with textiles, metals etc. Contribution of rubber in the field of engineering, space research, medical sciences, family planning etc. is vital.(R.Chandra, S.Mishra, 1995)

Actually, latex has divide by two types which is natural rubber latex and synthetic rubber latex (nitrile and neoprene). But in this study, a natural rubber latex $(C_5H_8)_n$ is used for a testing. In its natural state, rubber exists as a colloidal suspension in the latex of rubber-producing plants. Natural rubber latex (NRL) is a milky fluid that is produced by the *Hevea brazilienis* rubber tree found in Africa and Southeast Asia. Often, NRL is shortened to latex. Natural rubber is "**cis 1, 4-polyisoprene**" with the chemical structure of,