UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PREPARATION AND CHARACTERIZATION OF NATURAL RUBBER COMPOUND USING TREATED AND UNTREATED WASTE COOKING OIL AS GREEN PROCESSING OILS

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

DALGLISH ANAK WILLIAM

B051810069

970423-13-5765

FACULTY OF MANUFACTURING ENGINEERING

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: PREPARATION AND CHARACTERIZATION OF NATURAL RUBBER COMPOUND USING TREATED AND UNTREATED WASTE COOKING OIL AS GREEN PROCESSING OILS.

Sesi Pengajian: **2021/2022 Semester 2**

Saya **DALGLISH ANAK WILLIAM (970423-13-5765)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysiasebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

☑ TIDAK TERHAD

Disahkan oleh:

Alamat Tetap:
Lot 1763, Taman Hui Seng, Jalan Muhibah, 96700 Kanowit, Sibu Sarawak.

Tarikh: _____

ASSOCIATE PROFESSOR TS. DR. JEFFERIE BIN ABD. RAZAK
Cop Rasmi: CEng IMechE ; P.Tech MBOT
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka, Malaysia.

Tarikh: 27 / 7 / 2022

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Preparation and Characterization of Natural Rubber Compound using Treated and Untreated Waste Cooking Oil as Green Processing Oils" is the result of my own research except as cited in references.

Signature : .....

Author's Name : DALGLISH ANAK WILLIAM

Date : 27 June 2022

APPROVAL

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

27/7/2022

(TS. DR. JEEFFERIE BIN ABD RAZAK)
ASSOCIATE PROFESSOR TS. DR. JEEFFERIE BIN ABD. RAZAK
CEng IMechE ; P.Tech MBOT
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka, Malaysia.

ABSTRAK

Getah adalah bahan yang senang dijumpai dalam kehidupan seharian. Kebanyakanya, getah digunakan dalam pembuatan tayar, kasut dan juga komponen automotif. Sebatian getah terdiri daripada tiga komponen asas iaitu getah, minyak pemprosesan dan pengisi penguatan. Fungsi utama minyak pemprosesan adalah untuk menurunkan kelikatan dan meningkatan prestasi sebatian getah. Minyak aromatik seperti hidrokarbon aromatik polilik,sering digunakan dalam pembuatan produk getah kerana ia serasi dengan bahan tidak tepu. Walaubagaimanapun, minyak aromatik adalah berpontensi untuk menyebabkan kanser. Minyak pemprosesan aromatik boleh digantikan dengan alternatif yang lebih mesra alam. Oleh itu, sisa minyak makan yang telah dirawat, sisa minyak masak yang ditapis digunakan dalam penyelidikan minyak pemprosesan untuk getah sebatian. Kebimbangan tentang pengurusan sisa minyak masak telah timbul dan boleh memudaratkan alam sekitar. Dalam penyelidikan ini, sisa minyak makanan yang telah dirawat dan sisa minyak makan akan digunakan sebagai minyak pemprosesan untuk getah sebatian. Oleh itu, jumlah kuantiti minyak pemprosesan yang berbeza (0 phr, 5 phr, 10 phr, 15 phr, dan 20phr) telah digunakan untuk getah sebatian. Ciri-ciri penambahbaikan sifat sebatian getah yang mengunakan sisa minyak masak dan sisa minyak masak yang telah transesterifikasi adalah hampir sama. Keputusan dari uji kaji mekanikal dan fizikal sebatian getah tersebut menunjukkan perbezaan yang kecil di antara kedua-dua minyak pemprosesan ini. Kajian ini juga telah menunjukkan bahawa sisa minyak masak boleh digunakan sebagai minyak pemprosesan sejurus ditapis dari zarah yang tidak diingini. Kajian ini sangat penting kerana dapat meningkatkan kemungkinan untuk minyak pemprosesan yang baru dan kelebihan kepada produk daripada hasil sebatian getah.

ABSTRACT

Rubber is a material that is commonly encountered in daily life. Rubber is mostly used in tyre manufacturing, footwear, and automotive product. Rubber compounds are made up of three basic components: rubber, processing oils and reinforcing fillers. Processing oil is mainly used to lower the viscosity and improve the performance of rubber compounds. Aromatic oils, especially polycyclic aromatic hydrocarbons, are commonly utilized in the production of a variety of rubber compounds due to its compatibility with unsaturated materials. However, aromatic oils have the potential to cause cancer. These aromatic oils are frequently substituted with more environmentally friendly alternatives. Thus, this research discusses the possibility for chemically treated waste cooking oil and filtered waste cooking to be used as processing oils for the synthesis of rubber compounds. Waste management concerns related to used cooking oil have resulted in significant environmental implications. In this research, treated waste cooking oil, and waste cooking oil are utilized as processing oil for rubber compounds. Thus, different loadings of processing oils (0 phr, 5 phr, 10 phr, and 20 phr) were used in the rubber compound in this research. The rubber compound's cure characteristics show that the rubber compound with transesterification waste cooking oil and the waste cooking oil is almost similar. The result of mechanical and physical tests of natural rubber compounds treated with the waste cooking oil as the PO also shows a marginal difference between both of the processing oil. This study shows that the waste cooking oil can be used as processing oil after being filtered from the unwanted particle. This study is crucially significant since it will provide another possibility for oil processing that gives advantages to natural rubber compound products.

DEDICATION

To my beloved parents

William Anak Abang & Indai Pau Anak Urai,

my siblings

Olescynthya William & Samuel L. William,

my grandma

Poh Anak Meragan & Bahaga Anak Ugak,

my heroes

Abang Anak Entalai & Urai Anak Igoh.

I love you all. Thank you.

ACKNOWLEDGEMENT

"Glory be to the father, the son, and the holy spirit."

Better is the end of a journey in life than the beginning. I get hold of the grace of the Almighty God to begin and end all my final year projects in Jesus's name. Amen.

Deepest thanks to Ts. Dr. Jeefferie Bin Abd Razak, my respected supervisor, for his advice and commitment in supervising me through this whole research duration. His patience with my shortcomings was greatly appreciated. In addition, I also want to thank Sunrich Rubber Industry Sdn Bhd. and Puan Zallia for assisting me in conducting my PSM experiment. Furthermore, I'd want to express my gratitude to all of the assistant engineers who have lent me their expertise and knowledge in doing all of the necessary testing and laboratory tasks.

In closing, I want to express my gratitude to my housemates, who provided me with a lot of support and ideas for problem-solving. Thank you also to those I didn't include each and every one of you who is assisting me in completing this project, either directly or indirectly. May God bless you and shower you with hundreds of blessings for your kindness.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
ISO	-	International Organization for Standardization
ACS	-	American Cancer Society
WCO	-	Waste Cooking Oil
TWCO	-	Treated Waste Cooking Oil
EO	-	Engine Oil
SEM	-	Scanning Electron Microscope
PAH	-	Polycyclic Aromatic Hydrocarbon
PO	-	Processing Oil
AO	-	Aromatic Oil
FTIR	-	Fourier- Transform Infared Spectroscopy
OH-	-	Hydroxyl
CHG	-	Greenhouse Gas
FFA	-	Free Fatty Acids
NR	-	Natural Rubber
VE	-	Vulcanizable Elastomers
VGC	-	Viscocity Gravity Constant
DIOP	-	Diisooctylphtlate
PHR	-	Parts per Hundred of Rubber
SMR	-	Standard Malaysian Rubber
HAF	-	High Abrasion Furnace (Carbon Black Filler)

LIST OF SYMBOLS

wt. %	-	Weight Percentage
vl. %	-	Volume Percentage
%	-	Percentage
°C	-	Degree Celsius
σ	-	Stress
kJ	-	Kilojoules
min	-	Minute
mg KOH/g	-	Milligrams of Potassium hydroxide per gram oil Sample
Pa	-	Pascal
Mpa	-	Mega Pascal
g/ml	-	Gram per Milliliter
dNm	-	Deci Newton Meter
tc90	-	90% Curing Time
ts2	-	Scorch Time

CHAPTER 1

INTRODUCTION

The background of the study, problem statement, objectives, scope, the significance of the study, thesis organization, and overall summary were included in this chapter. A brief explanation on the experiment's background was also provided. In the background of the study write-up, brief statement on motivation of study, the novelty of the study and importance of the research were also included.

1.1 Research Background

In rubber compounding industry, processing oil is utilized to lubricate the rubber macromolecules and ease the mixing during compounding. They also helps in dispersing the filler and curatives. Thus, it was improved the natural and synthetic rubber compound's tensile strength and abrasion resistance. They are also responsible for increasing the physical qualities of natural and synthetic rubber compounds, such as elasticity, flex life, and lower temperature performance. The rubber compound has been developed for centuries to benefit humans for various importance technological application.

The rubber compound was mixture of between the natural rubber and other substances or known as curatives. The main reason for the mixing is to enhance the resulted strength of rubber vulcanization. As we know, raw natural rubber has limited usage due to its inferior properties. The rubber compound's numerous additional qualities might be improved when a specific substance is added. After the mixing, the rubber compound transforms into a more usable product (Ciesielski, 1999). As mentioned before, the rubber compound was mixed with multiple functional substances. This study has focused on the

usage of processing oil for the preparation and characterization of natural rubber compounds.

Commercial processing oil for rubber industries are extracted from crude oil that are also used for many applications. Processing oils are composed of saturated hydrocarbons with linear and branching chains, whereas aromatic oil is composed of unsaturated aromatic hydrocarbons. Heteroatoms, such as oxygen, nitrogen, and sulfur, are commonly found in aromatic oil. In aromatic oils, the existence of heteroatoms affects their solubility by imparting polarity to the almost nonpolar hydrocarbon oil structure. Furthermore, the aromatic oil would induce devulcanisation and depolymerisation when exposed to higher temperatures. The heteroatoms have the potential to react with free radicals, reducing the effectiveness of peroxide crosslinking. It was anticipated that the crosslink concentration of the rubber macromolecules will be reduced as a result of this reaction. Since the density of compounded rubber are directly connected to the resulting compound physical and mechanical characteristics, thus, the mechanical and physical qualities would be significantly reduced as well (Li et al., 2016).

Highly aromatic oil is derived from petrochemical sector byproducts and has traditionally been widely utilised as rubber compounding extender oils in the rubber compounding industry. Their efficiency can be ascribed to their ability to work with most elastomer types. It was indeed possible to detect aromatic hydrocarbons in consumer items which manufactured from the recycled rubber, and these compounds are discharged into the environment. Their entry into the human body occurs by leaching (soil, groundwater, rivers), oral intake, contact exposure, and inhalation. As a result, skin contact or inhalation are considered the significant routes of exposure, with oral ingestion and environmental pollution being considered as the secondary hazards. The amount of Polycyclic Aromatic Hydrocarbon (PAHs) that have the potential to damage humans' health is comparable to the amount of pollution seen in large cities (Diekmann et al., 2019). Due to that, aromatic oil utilisation can be reduced or avoided. It can be replaced by using an alternative source of less harmful oils such as recycled oil from waste such as cooking oil or treated engine oil.

Waste cooking oil is among the major cause for water pollution. It was produced after and during the preparation of meals in food industry. The waste cooking oil has the potential of damaging and harmful to the environment. As a result, the production of biofuel of waste cooking oil is perhaps the most viable solution, and additional research into the characterisation of waste cooking oil is overwhelmingly required. The waste of cooking oil

is comprised of the processed plant or animal fats.

Cooking oil is a glycerol ester composed of many forms of fatty acids that are only soluble in organic solvents, such as acetone. Waste is divided into two categories at room temperature which are fat and grease and liquid-shaped wastes. As a result of its insoluble nature in freshwater, it becomes a potential pollutant of the environment. Using waste cooking oil as an alternative fuel, biodiesel, or in a diesel engine has the beneficial potential. In order to manufacture the biodiesel-based product any source of fatty acids may be utilised, which means that if any plants or animals' lipid can be used as a substrate for the synthesis of biodiesel.

Biodiesel methyl-ester may be produced by using the transesterification process, in which the waste veggie oil or mammal fat interacts with alcohol in the presence of catalysts such as potassium hydroxide or sodium hydroxide. This is a more affordable and ecologically friendly alternative (Alias et al., 2018). When it comes to refining the waste oil, vacuum distillation as well as hydro-treatment are the favoured disposal alternatives in most nations. Combustion and incineration for energy recovery are other popular possibilities. However, due to the presence of undesired impurities in waste cooking oil, these disposal options are increasingly impracticable as environmental concerns as well as challenges which associated to costs (Lam et al., 2012).

The research aims of this study is to modify the waste cooking oil to be used as alternatives processing oil for the natural rubber compound. There are variety of bio-based resources which have great potential for replacing the petrochemical resources, including cooking oil, essential oil, palm oil, and a variety of other alternatives. In this research, the treated waste cooking oil and waste cooking oil to be used as processing oil for sustainable rubber compound. Moreover, this project has benefited in reducing the waste oil disposal problem caused by the waste oil as mentioned before and for the protection of the mother earth.

1.2 Problem Statement

Environmental problems have received more attention recently, resulting in high demand for new candidates of better alternative materials that are also environmentally friendly. The demand for rubber compound resources had increasing tremendously on the lateral side.

Various wastes are being used to substitute the commercially available resources. Wastes, or commonly known as by-products, resulting from industrial, agricultural, or households are generating no economic value, which must be appropriately disposed. Industrial wastes and by-products, whether solid or liquid-based, are abundantly available around the world. Environmental authorities in the majority of nations have enacted legislation and rules governing to the proper processing and disposal of waste oils. However, a significant quantity of this waste was illegally disposed of, posing severe environmental deterioration.

Each alteration made into rubber compound or procedure is likely to impact a broad range of the compound characteristics, whether uncured or cured, for the benefit or worse. As a result, every modification made to the rubber compound or production processes should be carefully studied prior to final application utilization. These modifications should be tested on a laboratory scale first to determine how they will impact the processability and cured physical and mechanical characteristics and the entire compound importance engineering properties.

Waste cooking oil is hazardous to the environment as well as to the health of those who exposed into it. According to the American Cancer Society (ACS), waste from frying oil is suspected to cause cancer due to the hazardous elements formed when the oil is oxidised from fried dishes. The majority of the by-products produced from the oxidation of cooking oil are toxic and carcinogenic. The disposal of waste cooking oil, on the other hand, will result in the obstruction of sewerage and drains. The dumping of waste cooking oil into the open water system will alter the oxygenation system and endanger the aquatic life because it will cover the water's surface and prevent oxygen from dissolving, so altering the processof oxygenation. Waste cooking oil has enormous potential for commercialisation since it may be utilised to manufacture goods such as biodiesel, which can help to minimise our reliance on natural resources. Waste cooking oil also has the potential to be recycled (Aliaset al., 2018).

Through the use of consumer items produced from reused rubber material has generated certain concerns about the discharge of hazardous chemical compounds into the environment. There is great concern about the prevalence of polycyclic aromatic hydrocarbons (PAHs) to the environment. These are complex mixes of organic materials whose chemical structure involves at least two or even more fused benzene rings, and in some cases, more than two. Polycyclic aromatic hydrocarbons have the potential to be carcinogenic, mutagenic, or reproductively toxic. Polycyclic aromatics have carcinogenic characteristics that are dependent to their molecular structures (Diekmann et al., 2019).

Cooking oil efficiency is comparable to that of aromatic as well as paraffinic oils. The results indicated that polymer compounds, including cooking oil has cured almost similar tothose cured by aromatic and paraffinic oils. It demonstrates that the cooking oil did not engage with the vulcanisation mechanism. Except, for rebound and resilience is different. The physical features of vulcanizates, including cooking oil, were nearly identical to those of vulcanizates. Cooking oil-containing vulcanizates possessed more resistance than aromatic and paraffinic oil-containing vulcanizates. This additional benefit was offered by cooking oil (Syamin et al., 2017).

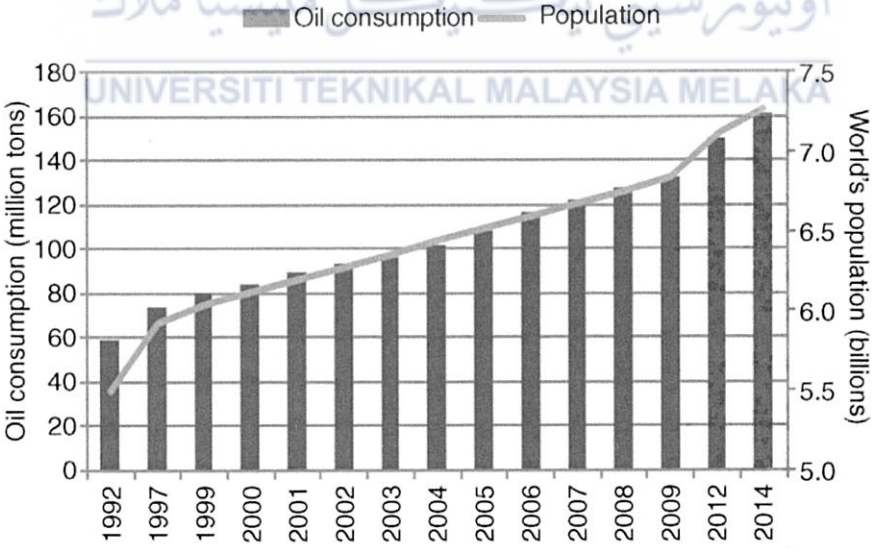

Figure 1.2: The consumption of Vegetable oil compared to the world population from 1992 until 2014 (Matthaus, 2016).

The above figure 1.2 shows the vegetable oil consumption as compared than the world pollution from year 1992 to 2014. The data shows that the consumption had increased from year to year. This is due to the vast production of vegetable oils to meet the global demand.Vegetable oil production and consumption has nearly quadrupled between the year of 1992and 2014 which is, from 59 Mt to 161 Mt. This growth in oil consumption has occurred concurrently with more or less linear increased in the world's population, from around 5.5 billion to more than 7 billion.

1.3 Objectives

The following are the research's objectives:

i. To evaluate the effects of loading variation for two different types of processing oil (untreated waste cooking oil and treated waste cooking oil) into the cure characteristic of natural rubber-based compounds by using the oscillating cure rheometer.

ii. To determine the effect of loading variation (0 phr, 5 phr, 10 phr, and 20 phr) of processing oil to the mechanical and physical properties of natural rubber-based compounds by using various related testing (tensile test, Shore-A hardness test, and density analysis).

iii. To relate the plasticiser effects of green processing oil addition with the fracture morphology of natural rubber-based compounds through the Scanning Electron Microscope (SEM) observation.

1.4 Scope of Study

The research scopes are as follow:

i. There is one type of processing oil that was utilized in this study which is the waste cooking oil. The processing oil that is tested are the untreated waste cooking oil and treated waste cooking oil.

ii. The weight percentages of the processing oil that was added to the natural rubber compound are 0 phr, 5 phr, 10 phr, and 20 phr. The 0 phr or non added sample was used as the control sample for the study.

iii. For testing the effect of processing oil to the natural rubber compound, both physical and mechanical testing were performed. The mechanical testing that was used is the tensile test and Shore-A hardness test. Meanwhile, the density testing has represented for the physical testing.

iv. For the cure characteristic, an oscillator cure rheometer test was performed to the entire uncured samples.

v. The frature morphology of the natural rubber compound was observed by using the Scanning Electron Microscope (SEM).

1.5 Significant of Study

Specifically, this research aims to evaluate and discover the possible usage of processing oil from the waste resources, including waste cooking oil and treated waste cooking oil.

This research could provide a better understanding on the effect to the rubber compound safter being loaded with processing oil. The mechanical properties and the physical properties were tested and evaluated. From the experimental result, the best candidate for processing oil has been chosen to be an alternative to the carcinogenic aromatic processing oil that are existingly used in common rubber industries. Next, the research is also to gain