UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOP FUTURE BIO-BASED LUBRICANT BY UTILISING NAN0-PARTICLES

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**A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours**

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2021

DECLARATION

I declare that this project entitled " Develop future bio-based lubricant by utilising nano-particles" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : YIP YUN YU

Date : 10/1/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours

Signature :

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Date :

DEDICATION

I dedicate this works to my beloved parents and my supervisor Dr. Muhammad Ilman Hakimi Chua Bin Abdullah, who offered unconditional love and support and have always been there for me. Thank you so much for giving me strength to finish my Final Year Project.

ABSTRACT

Different kinds of lubricants are obtainable all around the worldwide including mineral oils, synthetic oils, re-filtered oils, and vegetable oils. Mostly the lubricants that obtainable in the wholesale place are mineral oil extrated from petroleum oil in which that is not acceptable with the environment because of toxicity and low biodegradability ability. The use of vegetable oil as a lubricant has stimulated the interest of academics due to diminishing petroleum sources and environmental concerns. In comparison to mineral-based oils, vegetable-based lubricants have better real properties, corrosivity, and are limitless and biodegradable. Virgin biological oil or refined agricultural wastes may be used as a resource of bio-based lubricants. This thesis examined the virgin vegetable oil follow by utilizing the nanoparticles that used as additives to obtain an excellent tribology properties that can improve bio-based lubricants. This research found the nanoparticle that meet the basic requirement types and concentrations, then examine and find out the most suitable that can enhance wear protection and reduce friction. Hexagonal boron nitride (hBN) nanoparticles in place of lubricant additive was added into the vegetable oil to improve its physical and tribology properties. Four-ball-wear tests were completed on the extraction of vegetable oil along with the addition of hexagonal boron nitrate nanoparticles lubricated to each of the contact surface. As a results, nanoparticles improved the physical properties along with the good anti-wear and anti-friction characteristics of the lubricant mixtures comparing to the mineral oil. Vegetable oil have meet the basic criteria as bio-based lubricant and can replace the mineral oil as a new advanced renewable bio-based lubricant for industrial activities that concern to the environment and save cost.

ABSTRAK

Pelbagai jenis pelincir terdapat di seluruh dunia termasuk minyak mineral, minyak sintetik, minyak penapis semula, dan minyak sayuran. Sebilangan besar pelincir yang terdapat di pasaran adalah minyak mineral yang berasal dari minyak petroleum yang tidak dapat disesuaikan dengan persekitaran kerana ketoksikan dan tidak terbiodegradasi. Oleh kerana penurunan cadangan minyak dan masalah alam sekitar, pendekatan menggunakan minyak sayuran sebagai pelincir telah menarik perhatian para penyelidik. Sebagai perbandingan dengan pelincir berasaskan mineral, pelincir berasaskan minyak berasaskan sayur mempunyai sifat fizikal yang lebih baik, pelinciran tinggi, boleh diperbaharui, dan terbiodegradasi. Sumber pelincir berasaskan bio boleh menjadi minyak asli dara, atau sisa buah yang diproses. Tesis ini meneliti ekstrak minyak sayuran ke minyak nabati, dan nanopartikel digunakan sebagai bahan tambahan untuk mendapatkan pelumas berasaskan bio yang ditingkatkan secara teologi. Jenis dan kepekatan nanopartikel yang sesuai kemudian dinilai untuk meningkatkan perlindungan keausan dan mengurangkan geseran. Nanopartikel boron nitrida heksagon (hBN) sebagai bahan tambahan pelincir ditambahkan ke dalam sisa minyak sayur untuk meningkatkan sifat fizikal dan tribologinya. Empat ujian penggunaan bola dilakukan pada pengekstrakan minyak sayur dengan penambahan partikel nanopartikel hBN yang dilumasi dengan setiap sampel pelincir. Hasil eksperimen menunjukkan sifat fizikal yang lebih baik serta prestasi anti-haus dan anti geseran campuran pelincir berbanding minyak mineral. Minyak sayur dilihat sesuai untuk digunakan sebagai pelincir berasaskan bio baru yang dapat diperbaharui untuk aktiviti pembuatan yang sesuai dengan faedah penjimatan tenaga dan masalah alam sekitar.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBBREVIATIONS

hBN	-	Hexagonal boron nitride
Al_2O_3	-	Aluminium oxide
ASTM	-	American society for testing and materials
AFM	-	Atomic force microscopy
Cd	-	Cadmium
COOH	-	Carboxyl group
CMVOs	-	Chemically modified vegetable oils
CoF	-	Coefficient of friction
CuO	-	Copper(II) oxide
DLVO	-	Deryaguin–Landau–Verwey–Overbeek
EHC	-	Engineered hard chrome
EOR	-	Enhanced oil recovery
FA	-	Fatty acid
FAO	-	Food and agriculture organization
GDS	-	Glow discharge spectroscopy
Fe_3O_4	-	Iron(II,III) oxide
MWNT	-	Multi-surface materials
PAO	-	Poly alpha olefin
RTILs	-	Room temperature ionic liquids
SEM	-	Scanning electron microscopy
SWCNT	-	Single surface carbon monotubes
USDA	-	The United States Department of Agriculture
TiO_2	-	Titanium dioxide
WSD	-	Wear Scar Diameter
XRD	-	X-ray diffraction
ZnO	-	Zinc oxide
ZrO_2	-	Zirconium dioxide

CHAPTER 1

INTRODUCTION

1.1 Background

Vegetable oils are the collection of fats that are derived from food stuff cereal grains, nuts, seeds, fruits and even food waste. Based on the research, we need to understand that not all of these vegetable oils are liquid oils and at the range of surrounding temperatures or constant pressure (Hammond, 2013). The usage of vegetable oils and animal fats for lubrication resolutions already practiced for a few centuries. With the invention of petrol and thus the accessibility of economy oils, alternatives became unpleasant and were left by the roadside. (Fox and Stachowiak , 2007) found that selecting the correct waste vegetable oil added with nano-particles that can extract to bio-based lubricant will leading a way towards to sustainable future. The waste vegetable oil for example coconut, banana, papaya, corn, avocado, hemp oil palm, and soybean are the natural oil or pure organic elements that usually accustomed produce bio-based lubricant. There is no doubt that vegetable oils have excellent and outstanding properties such as high flash point, good lubricity, high viscosity index, high biodegradability, low evaporative loss and environmental friendly regarding to their use as feedstock and bio-based oil for lubricants (Madanhire & Mbohwa, 2016). “Today vegetable oil are gaining popularity and safe to use in variety field because of the excellent performance to our mother earth as the vegetable oil is a renewability resource, biodegradability, and easily decompose in the environment" (Gawrilow, 2003).

Bio-lubricants is also defined generally as materials that are supported biodegradable and renewable-based feed stocks (Madanhire & Mbohwa, 2016). Bio-based lubricant involves the annually renewable raw material utilized to construct the lubricant's base stock. Some samples of these base stock materials would be soybean, palm, rapeseed and sunflower products. For instance banana oil was used as lubricant since 1650BC (Gawrilow, 2003). These base stocks offers good lubricity, flash point and viscosity index properties but often are inferior in regard to their oxidation stability. Different kinds of oil are used in all fields of various projects mostly to drag out a long period of the worked machines by diminishing the existing of wear and grinding. Besides, bio-based lubricant derived from vegetable oil offers important environmental advantages in terms of its non-toxicity, biodegradability, renewability, and satisfactory performance in a wide array of applications (Lovell et al., 2006).

Recently, nanoparticles act a crucial characters as lubricant additives for their potential in emission reduction and improving gasoline economy. Nanoparticle may be a small particle normally less than 100nm, that undetectable by the human eye in order that it can display essentially extraordinary physical and chemical properties to their bigger material (Laurent et al, 2010). Why nano-particles are important to extract waste vegetable oil to bio-based lubricant? (Emami et al., 2005)explored that with the best nanoparticle in the extraction of vegetable oil, it can advance the performance for many industrial such as increase the storage and thermal stability, enhance the availability for food usage, coloring strength and industry manufacturing. Furthermore, the nano-particles such as triglyceride in vegetable oil provides awesome lubricity that contact to the metal surface, minimizing specific energy and cutting force. The nano-particles inside the vegetable coolant contains a big heat transmission coefficient that accelerate heat transmission above the tool-work piece boundary, and accordingly advance the external feature follow by decrease in turning force (Sharma et al., 2005).

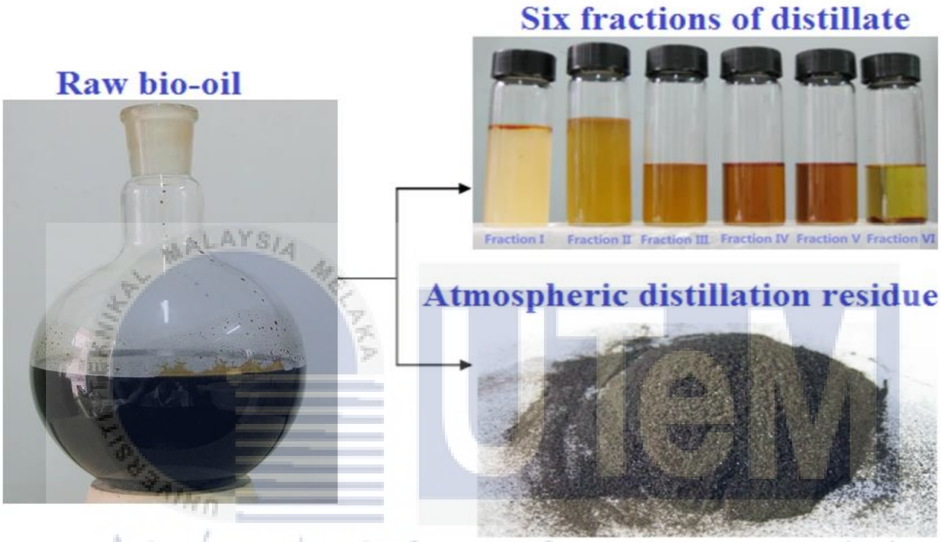

Figure 1.1. Example bio-based lubricant extraction by utilizing nanoparticles

1.2 Problem Statement

It is expected that, around 55 % of all mineral oil traded global result in the surroundings through spills, total loss applications, accidents or explosiveness. Over 96 % of these resources are mineral oil based such as petroleum. In view of their high eco-poisonousness and low biodegradability, mineral oil-based make up a considerable threat to the environment. (Gusain & Khatri, 2015)stated that roughly 3.5 billion gallons of lubricants are traded once a year in South African. Researches also additionally prove that much of this mixture (about 70%) is not accounted for and result in drain, ground water, rivers, lake and on the ground itself, causing uncountable danger to the ecosystem, agricultural and wildlife.

To overcome the problems that still using inorganic lubrication, the whole world attempt to substitute the synthetically and fuel based lubricants into the disposal, cost effective and environment approachable lubricants. To achieve a sustainable stability, it's the time now to use the lubricants that having minimum adverse outcome on the environment. Thus, waste vegetable oil plays an important role to extract itself to lubricant in their natural forms. Bio-based lubricant so called vegetable oil have an awesome lubricity, beyond compared to petroleum. In reality, their lubricity is so useful in some applications, such as tractor conveying and transmissions that having the problem of friction within materials must be added to minimize the clutch slippage" (Mobarak et al., 2014). Bio-based lubricants that extract from waste vegetable oil will be the replacements of the minerals oil-based lubricants due to their original physical properties and easy to dispose. Another source proved that the bio-based lubricant are beneficial as fundamental purpose in mechanical and manufacturing field. Last but not least, when it compare to the mineral oils the degradation percentage of vegetable oils 20–30% higher and that they are 94% eco-friendly. In fact, the use of bio-based lubricants can help to maintain our mother earth and forget about the demand on mineral oils in the future (Sharma et al., 2005).

i

1.3 Objective

The objective of this project are stated as below;

1. To examine suitable vegetable oil as based oil for developing bio-based oil.
2. To formulate new bio-based oil from vegetable oil with addition of hBN nanoparticles as additives.
3. To test and analyse the performance of new bio-based lubricant.

1.4 Scope of Research

The scope of this research are as follows:

1. Developing the bio-based oil by using vegetable oil as a primary based oil.
2. Formulating pure bio-based oil accordingly to ASTM by addition of hBN nano-particles.
3. Testing the develop bio-based oil according to ASTM P417.
4. Analysing the surface petrology for develop bio-based oil.

CHAPTER 2

LITERATURE REVIEW

2.1 Problem of synthetic oil

Synthetic oils are delivered through cycles of the production of petrochemical industry crude products or in the hydro reactant interaction of hydrocarbon spine change after manufactured oil. On the planet, more than 85% of manufactured base-oils are delivered from three principle combination of materials that are poly-alpha-olefins (45%), esters, including dibasic esters, polyol esters (25%), and polyalkylene glycols (PAGs) (15%) (Schneider, 2006). Maximum majority completely manufactured oils are PAO oils. The reason is the way that oils of this sort get portrayed by a generally great productivity, yet additionally moderately exorbitant cost. Tragically, some engineered oils can likewise represent a danger to the climate. The reason is because the synthetic oil cause pollution toward the environment by contributing a massive amount of chemicals, waste and carbon emissions although the synthetic oils are cheap and easier to produce in large quantities.

Synthetic oil is produced into the surrounding as oil vapour and nano drops, representing a significant hazard to the surrounding (Guerra et al., 2018). Strength and impacts of connections of oil subsidiaries are firmly identified with the arrangement, discharge dimensions and recurrence at a given region, and characterisations of a gadget with an open cutting application. Mineral oils are a low biodegradability lubricant. Ferro and Smith wrote in 2007 that, “In the natural environment, oil of petroleum origin creates primary hazards for sawing operators, but also secondary hazards due to the accumulation of oils in plant, animal,