EFFECT OF BIODIESEL PRODUCTION BASED ON ZINC OXIDE SUPPORTED SILICA OXIDE CATALYST

MUHAMMAD FERNANDA BIN SAIFUL

B091910268

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (TECHNOLOGY AUTOMOTIVE) WITH HONOURS

2022

Faculty of Mechanical and Manufacturing Engineering Technology

EFFECT OF BIODIESEL PRODUCTION BASED ON ZINC OXIDE SUPPORTED SILICA OXIDE CATALYST

MUHAMMAD FERNANDA BIN SAIFUL

Bachelor of Mechanical Engineering Technology (Technology Automotive) with Honours

2022

EFFECT OF BIODIESEL PRODUCTION BASED ON ZINC OXIDE SUPPORTED SILICA OXIDE CATALYST

MUHAMMAD FERNANDA BIN SAIFUL

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

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this Choose an item. entitled "**EFFECT OF BIODIESEL PRODUCTION BASED ON ZINC OXIDE SUPPORTED SILICA OXIDE CATALYST**" 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 : MUHAMMAD FERNANDA BIN SAIFUL

Date : 11 JANUARY 2023

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 Bachelor of Mechanical Engineering Technology (Technology Automotive) with Honours.

Signature : Haizal

Supervisor Name : DR. MOHD HAIZAL BIN MOHD HUSIN

Date : 11 january 2023

DEDICATION

For my family.

ABSTRACT

Petrol with a lot of used to the car somedays it will run out and limit to use and biodiesel will be the substitute to the petrol to be the fuel of the car. An experimental investigation were conducted to know the effect of biodiesel production based on zinc oxide support by silica oxide. The use of heterogenous catalyst by wet impregnation method was performed with the different percentage weight over weight of catalyst with differents temperature of calcination to make a high quality green biodiesel. Catalyst characterization which are XRD and SEM were conducted in this experiment to check the zinc oxide and silica oxide exist in the catalyst. Transesterification process were performed using the waste cooking oil (WCO) as a main feedstock to determine the acid value and free fatty acid of each of the catalyst. The results are using 5% percentages weight over weight of the zinc oxide supported by silica oxide will produce lowest acid value and free fatty acid.

ABSTRAK

Petrol yang banyak digunakan untuk kereta suatu hari nanti ia akan kehabisan dan terhad untuk digunakan dan biodiesel akan menjadi substitusi kepada petrol untuk menjadi bahan api kereta. Penyiasatan eksperimen telah dijalankan untuk mengetahui kesan penghasilan biodiesel berdasarkan sokongan zink oksida oleh silika oksida. Penggunaan mangkin heterogen melalui kaedah impregnasi basah dilakukan dengan peratusan berat yang berbeza berbanding berat mangkin dengan suhu pengkalsinan yang berbeza untuk menghasilkan biodiesel hijau berkualiti tinggi. Pencirian mangkin iaitu XRD dan SEM telah dijalankan dalam eksperimen ini untuk memeriksa kewujudan zink oksida dan silika oksida dalam mangkin. Proses transesterifikasi dilakukan menggunakan sisa coking oil (WCO) sebagai bahan suapan utama untuk menentukan nilai asid dan asid lemak bebas setiap mangkin. Keputusan menggunakan 5% peratusan berat berbanding berat sokongan zink oksida oleh silika oksida akan menghasilkan nilai asid terendah dan asid lemak bebas.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Dr. Mohd Haizal Bin Mohd Husin, from from, Faculty Technology Mechanical and Manufacturing, Universiti Teknikal Malaysia Melaka (UTeM) for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered. Also, to my academic supervisor, TS. Khairil Amri Bin Kamaruzzaman, Universiti Teknikal Malaysia Melaka (UTeM) who constantly supported my journey. My special thanks go to Amiera Husna student master at Universiti Teknikal Malaysia Melaka (UTeM) for all the help and support I received from them.

Last but not least, from the bottom of my heart a gratitude to my beloved parents, Saiful Bin Abd Rahman and Erlina Farida, for her encouragements and who have been the pillar of strength in all my endeavors. I would also like to thank my friend, Aiman Ashri Bin Arifuddin for the endless support and patience to finish this works. Finally, thank you to all the individual(s) who had provided me the assistance, support, and inspiration to embark on my study.

TABLE OF CONTENTS

		PAGE
DECLARATION		
APPROVAL		
DEDICATION		
ABSTRACT		**i**
ABSTRAK		**ii**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENTS		**iv**
LIST OF TABLES		**vi**
LIST OF FIGURES		**vii**
LIST OF SYMBOLS AND ABBREVIATIONS		**viii**
LIST OF APPENDICES		**ix**
CHAPTER 1	**INTRODUCTION**	**10**
1.1	Background	10
1.2	Problem Statement	12
1.3	Objectives	12
1.4	Scope of Research	13
CHAPTER 2	**LITERATURE REVIEW**	**14**
2.1	Biodiesel background	14
	2.1.1 Feedstock of biodiesel	16
	2.1.2 Biodiesel's Advantages	17
	2.1.3 Cons of biodiesel	18
2.2	Raw material	19
	2.2.1 Zinc chloride	19
	2.2.2 Silica oxide	20
	2.2.3 Alcohol	22
2.3	Heterogenous catalyst	23
	2.3.1 Acid catalyst	23
	2.3.2 Base catalyst	24
2.4	Biodiesel production method	25
	2.4.1 Biodiesel produced by transesterification	25
	2.4.2 Conventional transesterification method	28
	2.4.3 Ultrasonic irradiation transesterification method	28
	2.4.4 Microwave irradiation transesterification method	29

2.5 Non-edible source to produce biodiesel 30
2.5.1 Waste cooking oil 30
2.5.2 Algal oil 31
2.5.3 Vegetable oil 31
2.5.4 Waste animal oil 32
2.6 Standard of biodiesel 33

CHAPTER 3 METHODOLOGY 35
3.1 Instruments and raw materials 35
3.1.1 Zinc chloride, $ZnCl_2$ 35
3.1.2 Silica oxide, SiO_2 35
3.1.3 Chemical 36
3.1.4 Apparatus 36
3.2 Biodiesel production process 37
3.3 Catalyst preparation 38
3.3.1 Catalyst characterization 40
3.4 Transesterification process 41
3.5 Fuel properties testing 43
3.5.1 Acid value and free fatty acid 43

CHAPTER 4 RESULTS AND DISCUSSION 44
4.1 Introduction 44
4.2 Characteristics of Waste Cooking Oil (WCO) 45
4.3 Chacterization of the catalyst 45
4.3.1 X-ray Diffraction (XRD) 46
4.3.2 SEM 46
4.4 Effect on the transesterification process 48
4.4.1 Acid value of 1% catalyst vs Temperature 48
4.4.2 Acid for different weight over weight at optimum temperature 49
4.4.3 Free fatty acid of catalyst 51

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS 53
5.1 Conclusion 53
5.2 Recommendation 54
5.3 Project Potential 54

REFERENCES 55

APPENDICES 57

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1	Charateristics of Biodiesel (US DEPARTMENT OF ENERGY, Alternative Fuel Data Center)	15
Table 2.2:	Properties of zinc chloride.	20
Table 2.3	Properties of the silica oxide, SiO2 (AZO MATERIALS, 2020)	21
Table 2.4	The ASTM D6751 and EN 14214 biodiesel test techniques and criteria are compared to those of petroleum diesel.	33
Table 4.1	Characteristics of WCO	45
Table 4.2	SEM element of catalyst	47
Table 4.3	1% Catalyst result for transesterification process	48
Table 4.4	Acid value for different w/w of catalyst	50
Table 4.5	FFA of catalyst	51

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	Some feedstocks for biodiesel synthesis (P. Dasta, A. Pratap Singh,2022)	16
Figure 3.1	Biodiesel production flow chart	37
Figure 3.2	Catalyst preparation	40
Figure 3.3	The separation of solution in the oil mixture with the catalyst	42
Figure 4.1	XRD catalyst for Zinc oxide supported by silica oxide	46
Figure 4.2	SEM of zinc oxide supported silica oxide x1000 image	47
Figure 4.3	1% ZnO support SiO_2 acid value vs temperature	49
Figure 4.4	Acid value at optimum temperature vs w/w of catalyst	50
Figure 4.5	Free fatty acid vs Acid value	51

LIST OF SYMBOLS AND ABBREVIATIONS

ZnO	-	Zinc oxide
SiO_2	-	Silica oxide
$ZnCl_2$	-	Zinc chloride
WCO	-	Waste cooking oil
ASTM	-	American Society of Testing and Materials
MeOH	-	Methanol
KOH	-	Potassium Hydroxide
W/W	-	Mass percentage of solute in solution
^oC	-	Degree celcius
AV	-	Acid Value
EN	-	European Standards
FFA	-	Free fatty acid
XRD	-	X-ray diffraction

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX 1	Gantt Chart PSM 1	57
APPENDIX 2	Gantt Chart PSM 2	58
APPENDIX 3	Weight over weight calculation	59
APPENDIX 4	Methanol to oil ratio calculation	59

CHAPTER 1

INTRODUCTION

1.1 Background

Crude oil and coal, among other fossil fuels, have long been the world's principal energy sources, whether for personal, industrial, or transportation use. On the other hand, traditional energy sources are connected to environmental problems and depletion. Due to the issues outlined above and growth in energy consumption due to overpopulation and the development of companies, energy expert’s focus has recently switched to alternative energy sources. Biofuels like biohydrogen, biogas, and biodiesel have some of the above characteristics, with biodiesel being the most promising (A.S. Yusuff, A.K. Bhonsle, J. Trivedi et al 2021).

Mono-alkyl esters of vegetable oils or animal fats are used to make biodiesel. Biodiesel contributes to environmental preservation by lowering sulphur oxide emissions, is biodegradable, renewable, non-toxic, and has a lower greenhouse gas effect.

Biodiesel has been effectively created from plant oil, animal fat, and waste oil using the transesterification process, which has received a lot of interest. The reaction takes place in the presence of an appropriate catalyst, which might be homogeneous or heterogeneous, to complete the response quickly.

According to (A.S. Yusuff, A.K. Bhonsle, J. Trivedi et al (2021), homogeneously catalyzed transesterification has several drawbacks, including a time-consuming purification method and the formation of wastewater during the biodiesel washing process, as well as a high manufacturing cost. These problems may be solved by a heterogeneous catalyzed transesterification process, which lowers the total biodiesel production costs. Using a solid catalyst eliminates the need to wash the crude biodiesel and allows the catalyst to be reused several times.

The pick of heterogeneous catalyst is a better choice for many advantages such as low cost required, ease to control or manipulation and ease of getting the catalyst. According to A.S. Yusuff, A.K. Bhonsle, J. Trivedi et al (2021), certain researchers have also employed heterogeneous catalysts to generate biodiesel. Heterogeneous catalysts, according to P. Maheshwari et al (2022), also aid in rapid recycling and reuse, resulting in a cost-effective green technique. Transesterification, a lipid reaction with alcohol, is a typical way to make biodiesel fuel. According to P. Maheswari et al (2022), alcoholysis (alcohol-cleavage) is the process by which alcohol displaces an ester. The approach produces a mixture of fatty acid esters as a result of chemical reactions. Biodiesel is produced by separating fatty acid methyl esters from a mixture (FAME). The process may be sped up by catalysts, which come in various forms. Zinc oxide will be utilized as a catalyst to combine with silica oxide in this experiment.

1.2 Problem Statement

Nowadays a lot of cars used a petrol as a fuel to make the car working or moving. After a lot of petrol used maybe one day it can cause petrol to finished the future. Biodiesel werre produced to be used for the future if petrol is limited in future. Biodiesel is a substitute for the petrol because it also has lot of advantages such as renewable fuel, and have low pollution compared to petrol fuel. A lot of catalyst were produced in this world to produce a biodiesel oil. The amount of catalyst used were quite a lot. The limitation of producing biodiesel fuels are quite expensive such as zinc chloride and silica oxide. In this study, the catalyst were reduced to produce a high green quality biodiesel. With the little amount of catalyst, it can reduce the cost to produce the biodiesel oil. Next, a lot of time were taken when producing catalyst. In this study, the little amount of catalyst will undergo the wet impregnantion method, the drying process will more faster with a little amount of catalyst.

1.3 Objectives

This research aims to produce biodiesel using a zinc oxide that acts as a catalyst to mix with the silica oxide as a supported. Specifically, the objectives are as follows:

a) To prepare and characterized the differents percentage weight over weight samples which are 1%, 2%, 3%, 4%, and 5% of zinc oxide mix with silica oxide as catalyst.

b) To examine the fuel properties, zinc oxide mix with silica oxide with differents percentage of weight over weight.

1.4 Scope of Research

The scope of this research is as follows:

i. Producing zinc oxide supported by silica oxide with differents w/w samples as biodiesel production feedstock.

ii. Performing the transesterification process for the sample to produce biodiesel fuel.

iii. The biodiesel production must check the free fatty acid, and acid value to meet ASTM D6751 standard.

CHAPTER 2

LITERATURE REVIEW

2.1 Biodiesel background

Coal, oil, microalgae, and natural gas are the primary energy sources in the world. However, since these resources are limited, biofuels are employed as a renewable energy resource to reduce pollution and concerns about fossil fuel supplies in the medium and long term. Because of its environmental advantages, the global demand for biodiesel has skyrocketed, with global output reaching 140 billion litres in 2017 (Marimuthu Prabu and colleagues, 2019).

US biodiesel producers turn to waste oils and fats from the food and restaurant industries to develop this renewable fuel source. US DEP's Alternative Fuel Data Center says that biodiesel fulfills the renewable fuel Standard's biomass-based diesel and overall advanced biofuel criteria. Biodiesel is a liquid fuel often referred to as B100 or plain biodiesel when sold in its pure, unbleached form. Table 2.1 shows lists all of the physical properties of biodiesel. Everything has the characteristics that biodiesel manufacturing requires.

Table 2.1 Charateristics of Biodiesel (US DEPARTMENT OF ENERGY, Alternative Fuel Data Center)

Properties	Value
Specific gravity	0.88
Kinematic viscosity at 40^{0}C	4.0 to 6.0
Cetane number	47 to 65
Higher heating value, Btu/gal	~127960
Lower heating value, Btu/gal	~119500
Density, lb/gal at 15.5^{0}C	7.3
Carbon, wt%	77
Hydrogen, wt%	12
Oxygen by dif., wt%	11
Boiling point, ^{0}C	315-350
Flash point, ^{0}C	100-170
Sulfur, wt%	0.0 to 0.0015
Cloud point, ^{0}C	-3 to 15
Pour point, ^{0}C	-5 to 10

When it comes to its chemical composition, it is mostly composed of fatty acid methyl esters (FAMEs), which have many of the same chemical properties as petroleum-based diesel fuels. According to Marimuthu Prabu et al (2019), biodiesel may be used in compression ignition engines with few or no modifications. The use of varied mix ratios of biodiesel to achieve high cetane numbers and lubricity is also noteworthy.

Flashpoint, methanol and water and sediment, kinematic viscosity, sulfated ash, copper strip corrosion, cetane number, cloud point, acid number and carbon residue, total and free glycerin, phosphorus and reduced pressure distillation temperature, atmospheric equivalent temperature, combined calcium and magnesium, and combined sodium and magnesium are all required for a standard specification according to ASTM D6751.

2.1.1 Feedstock of biodiesel

The kinds of oil that may be utilized as biodiesel sources are listed in Table 2.1. From the seed oil, there is both edible and non-edible oil. Aside from it, the feedstock included waste cooking oil, sewage sludge, and other urban garbage. The next source of biodiesel feedstock was microbial oil, including microalgae, yeast, fungus, and bacteria. India is the world's third-largest primary energy and oil user, behind the United States and China. According to the Government of India's Ministry of Petroleum and Natural Gas, demand for petroleum products will be over 25 107 tonnes in 2022. (Tiewsoh et al 2019).

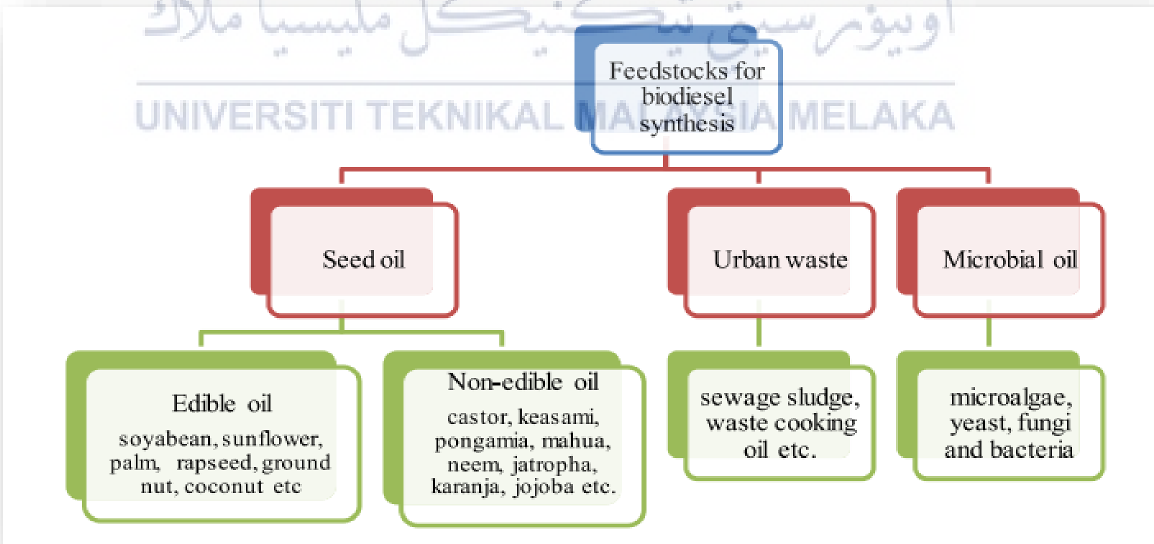

Figure 2.1 Some feedstocks for biodiesel synthesis (P. Dasta, A. Pratap Singh,2022)

2.1.2 Biodiesel's Advantages

The reduction of NOx, CO, sulphur, and polyaromatic hydrocarbons benefits biodiesel as a fuel additive, resulting in a reduced environmental effect (Marimuthu Prabu and colleagues, 2019).

There are at least five reasons why biodiesel is being produced, even though it cannot completely replace petroleum-based diesel. Vegetable and animal fats produced in excess may be sold in this market. The country's reliance on petroleum imports is also lessened, although it is not entirely removed. Biodiesel is a renewable fuel with no impact on climate change due to its closed carbon cycle. To put it another way, biodiesel decreases CO_2 emissions by 78% compared to petroleum-based diesel fuel. Carbon monoxide and unburned hydrocarbon emissions, as well as particulate matter, are reduced when using biodiesel as opposed to conventional diesel. A little rise in nitrogen oxides has been seen in most of the emissions testing, which is disappointing (NOx).

A study by the US Department of Energy's Alternative Fuel Data Center shows that biodiesel raises the cetane number of gasoline while also improving lubricity. In response to government rules that limit sulphur level to 15 parts per million and lower aromatic content, the lubricity of petroleum diesel has been reduced. A lubrication requirement was added to the ASTM D975 diesel fuel standard to correct this. Little blend percentages of biodiesel, as low as 1%, may improve diesel fuel lubricity.

2.1.3 Cons of biodiesel

Biodiesel may be made from a variety of biofuel crops. When oil is extracted and chemically transformed to fuel, the ability to generate electricity varies. Because of the variable content of vegetable oil, no two biofuel crops are exactly same. Additionally, although biodiesel might boost an engine's efficiency, it can also damage the rubber casing of certain engines. Consider all of these issues before making a switch to biodiesel. Increased demand for these items, which are derived from animal and vegetable fat, might lead to price increases and, as a consequence, a food shortage in certain regions. Demand for biodiesel derived from maize might lead to a rise in prices, making it more difficult for impoverished people to get it. Biodiesel reduces engine sludge with ease. Biofuels have the advantage of not blocking the fuel filter when dirt settles in, but the disadvantage is that biofuels clog the fuel filter. In terms of availability, biodiesel isn't as widespread as petroleum diesel. Engine operation will not become more efficient unless the infrastructure is improved. Soy-based biodiesel production requires a large amount of energy, as does the process of growing, fertilising, and harvesting the crops. As a result, cars may be required to transport raw materials, which might need more petroleum.