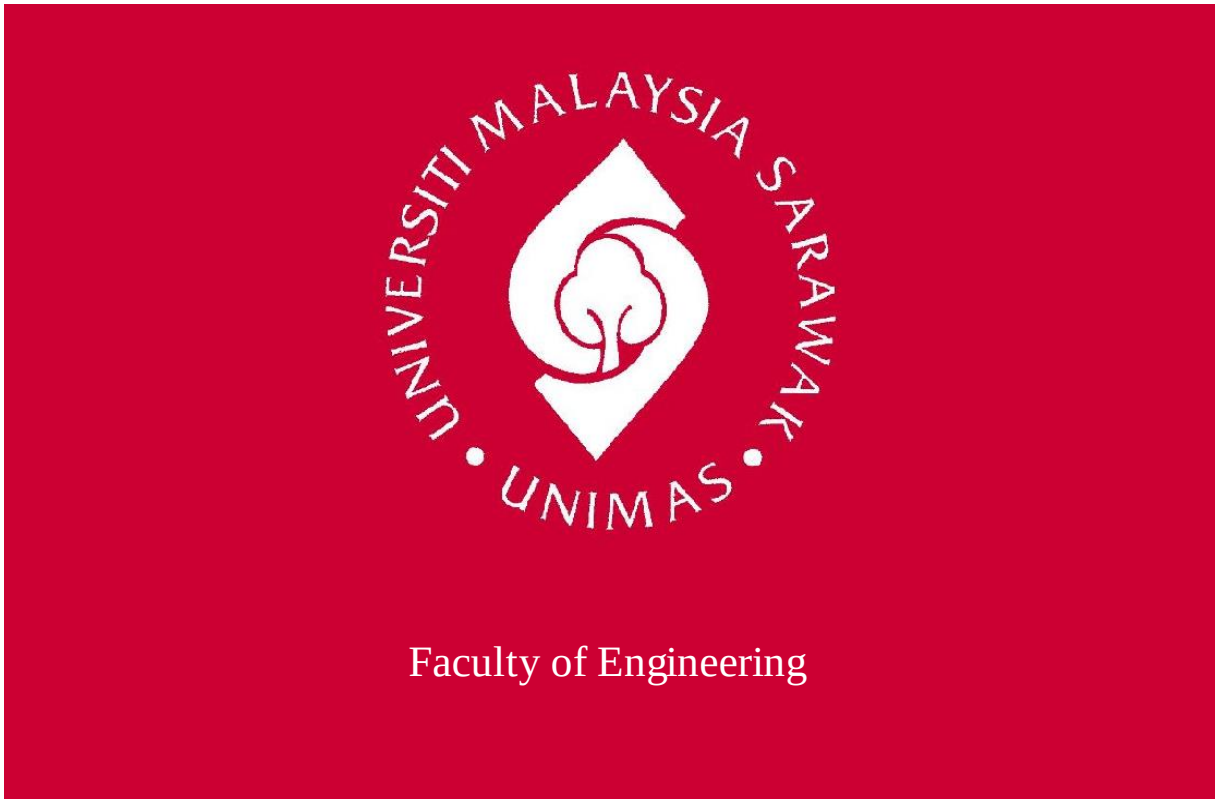

SYNTHESIS OF BIODIESEL FROM SUNFLOWER OIL ASSISTED WITH GINGER LEAVES FOR ENERGY APPLICATION

MONNIE ANAK JOHN

Bachelor of Engineering with Honours

(Chemical Engineering)

2020

UNIVERSITI MALAYSIA SARAWAK

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24 JULY 2020

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(Final Year Project Supervisor)

Date

SYNTHESIS OF BIODIESEL FROM SUNFLOWER OIL ASSISTED WITH GINGER LEAVE FOR ENERGY APPLICATION

MONNIE ANAK JOHN

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering with Honours
(Chemical Engineering)

Faculty of Engineering
Universiti Malaysia Sarawak

2020

Dedicated to my beloved parents, sibling and friends who always bestow me sustainable motivations and encouragements.

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ABSTRACT

Biodiesel tends to be a potential substitute for non-renewable fossil fuels, although the production indicated the presence of a catalyst to speed up the reaction. In order to find heterogeneous catalysts that are beneficial, cost-effective and environmental friendly. This study utilized the leaves of ginger plant in three different types, calcined (CGL), activated by KOH (KGL) and activated by NaOH (NGL). The properties of respective catalyst types were characterized using SEM, BET and FTIR, studied are well comparable with reported literatures. Operating conditions measured for the three catalysts were reaction time (from 30 to 180 min), methanol to oil ratio (from 4:1 to 10:1) and catalyst loading (from 0.5 to 3.9 wt.%). The ginger leaves activated by KOH obtained the highest biodiesel yield (93.83%) and optimum conditions obtained in 90 minutes of heating, 6:1 alcohol to oil molar ratio and 1.6 wt.% catalyst load. The process energy indices and economic analysis were evaluated to examine the possible advantages of sunflower oil in biodiesel production. The data of this analysis was average assembled from various research paper of agricultural wastes to synthesis catalyst. The total amount of energy input in this reaction for biodiesel production using CGL, KGL and NGL as a catalyst 33.38 MJ/L, 44.72 MJ/L and 38.88 MJ/L, respectively. The energy use efficiency, specific energy and energy productivity of CGL catalyst were 1.4157, 24.3811 MJ/kg and 0.0410 kg/MJ, while KGL catalyst were 1.2728, 26.1544 MJ/kg and 0.0382 kg/MJ and those of NGL catalyst were 1.3524, 25.0267 MJ/kg and 0.040 kg/MJ, respectively, as producing one litre of biodiesel were determined. The renewable energy and non-renewable energy of CGL catalyst (76.03% and 23.97%), while KGL catalyst (80.03% and 19.97%) and those of NGL catalyst (78.57% and 21.43%), respectively, were obtained. Also, economic efficiency for CGL, KGL and NGL catalyst was achieved at 0.4373 kg/RM, 0.4088 kg/RM and 0.4260 kg/RM, respectively.

Keywords: Biodiesel, transesterification, ginger leaves, sunflower oil, solid catalyst, alkali activation, energy efficiency, energy ratio, productivity, renewable energy

ABSTRAK

Biodiesel cenderung menjadi pengganti yang berpotensi untuk bahan bakar fosil yang tidak dapat diperbaharui, walaupun produksi menunjukkan adanya pemangkin untuk mempercepatkan reaksi. Untuk mencari pemangkin heterogen yang bermanfaat, menjimatkan kos dan selamat dari persekitaran. Kajian ini menggunakan daun tanaman halia dalam tiga bentuk yang berbeza, dikalsinasi (CGL), diaktifkan oleh KOH (KGL) dan diaktifkan oleh NaOH (NGL). Sifat-sifat bentuk pemangkin yang berbeza ditentukan menggunakan SEM, BET dan FTIR dikaji dapat dibandingkan dengan literatur yang dilaporkan. Parameter operasi yang dikaji untuk ketiga-tiga pemangkin adalah masa reaksi (dari 30 hingga 180 min), nisbah metanol ke minyak (dari 4: 1 hingga 10: 1) dan pemangkin pemangkin (dari 0,5 hingga 3,9% wt.). Daun halia yang diaktifkan oleh KOH memperoleh hasil biodiesel tertinggi (93.83%) dan keadaan optimum diperolehi pada pemanasan 90 minit, nisbah molar alkohol ke minyak 6: 1 dan 1.6% berat pemangkin berat. Indeks tenaga proses dan analisis ekonomi dinilai untuk memeriksa kemungkinan kelebihan minyak bunga matahari dalam pengeluaran biodiesel. Data analisis ini rata-rata dikumpulkan dari berbagai kertas penyelidikan sisa pertanian menjadi pemangkin sintesis. Jumlah input tenaga dalam tindak balas ini untuk pengeluaran biodiesel menggunakan CGL, KGL dan NGL sebagai pemangkin masing-masing 33.38 MJ/L, 44.72 MJ/L dan 38.88 MJ/L. Kecekapan penggunaan tenaga, tenaga spesifik dan produktiviti tenaga pemangkin CGL adalah 1.4157, 24.3811 MJ/kg dan 0.0410 kg/MJ, sementara pemangkin KGL adalah 1.2728, 26.1544 MJ/kg dan 0.0382 kg/MJ dan katalis NGL adalah 1.3524, 25.0267 MJ/kg dan 0.040 kg/MJ, masing-masing, untuk menghasilkan satu liter biodiesel dikira. Tenaga boleh diperbaharui dan tenaga tidak boleh diperbaharui pemangkin CGL (76.03% dan 23.97%), sementara pemangkin KGL (80.03% dan 19.97%) dan katalis NGL (78.57% dan 21.43%), masing-masing, diperoleh. Kecekapan ekonomi untuk pemangkin CGL, KGL dan NGL dicapai masing-masing pada 0.4373 kg/RM, 0.4088 kg/RM dan 0.4260 kg/RM.

Kata kunci: *Biodiesel, transesterifikasi, daun halia, minyak bunga matahari, pemangkin pepejal, pengaktifan alkali, kecekapan tenaga, nisbah tenaga, produktiviti, tenaga boleh diperbaharui*

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ABBREVIATION

AEC	Atomic Energy Commission
AEAC	Acid Equivalent Antioxidant Capacity
ASTM	American Society of Testing and Materials
BET	Brunner, Emmett and Teller
C	Carbon
CaO	Carbon Oxide
CGL	Calcined Ginger Leaves
DG	Diglycerides
DPPH	2,2-Diphenyl-1-Picrylhydrazyl
EEA	European economic area
EIc	Energy input conversion
EIe	Energy input extraction
EIr	Energy input refining
EIPt	Total energy input for production
EN	European Union
EP	Energy Productivity
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
ER	Energy Ratio
EROI	Energy Return On Invested
FAME	Fatty acid methyl esters
FIC	Ferrous Ion-Chelating
FFA	Free Fatty Acid
FTIR	Fourier transform infrared spectroscopy
GL	Glycerol
HCl	Hydrochloric Acid
Na_2O_2	Sodium Peroxide
H_2SO_4	Sulphuric Acid
kBr	Potassium bromide
KGL	KOH – Activated Ginger Leaves
KOH	Potassium Hydroxide

LCA	Life Cycle Analysis
MG	Monoglycerides
Na	Sodium
NaOH	Sodium Hydroxide
NEG	Net Energy Gain
NEP	Net Energy Production
NGL	NaOH – Activated Ginger Leaves
OH	Hydrogen Oxide
R	Organic group
RME	Repair maintenance energy
SE	Specific Energy
SEM	Scanning electron microscopy
SZ	Sulphonated Zirconia
TGA	Triacylglycerol
TG	Triglycerides
TPC	Total Phenolic Content
USD	United States Dollar
U.S	United States

NOMENCLATURE

β	Beta
%	Percentage
°C	Degree Celsius
°F	Degree Fahrenheit
K	Kelvin
L	Litre
M	Molar mass
N	Normality
μm	Micrometre
Kg	Kilogram
MJ	Megajoule
mg	Milligram
mL	Millilitre
ha	Hectare
hr	Hour
pH	Potential Hydrogen
ppm	Parts per million
cm^{-1}	Centimetre
g/cm^3	Gram per cubic centimetre
Kg/L	Kilogram per litre
Kg/m^3	Kilogram per cubic metre
Kg/MJ	Kilogram per megajoule
Kg/RM	Kilogram per Ringgit Malaysia
kJ/kg	Kilojoule per kilogram
kJ/mol	Kilojoule per mole
kWh	Kilowatt hour
L/million	Litre per million
mg AA/g	Milligram Ascorbic Acid per gram
mg GAE/g	Milligram Gallic Acid Equivalent per gram
mg KOH/g	Milligram Potassium Hydroxide per gram
mg/kg	Milligram per kilogram

m^2/g	Square metre per gram
mm^2/s	Square millimetre per second
MJ/ha	Megajoule per hectare
MJ/kg	Megajoule per kilogram
MJ/L	Megajoule per litre
MJ/t	Megajoule per tonne
L/ha	Litre per hectare
h/ha	Hour per hectare
RM/L	Ringgit Malaysia per litre
$/acre	Dollar per acre
$/year	Dollar per year
w/w	Weight by weight
wt	Weightage

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Energy security, environmental concerns, growing industrial development and quality of life society throughout the nation becomes a key factors to be recognize as a leading force to search for reliable sources of energy (Owusu & Sarkodie, 2016). Fossil fuels have been the only main energy source and were used worldwide on a continuous basis over the last few decades (Zou et al., 2016). The alternative renewable energy such as biomass have drawn astonishing worldwide attention. This renewable energy sources, biomass which include agricultural and forest management oriented materials are widely investigated to generate liquid fuels for an possible choice to petroleum fuels (Moreno et al., 2019). Biodiesel are mostly as renewable fuel consists of a long chain ester carboxylic acid alkyls combination (Mumtaz et al., 2017). It seems to be an possible substitute diesel fuel as an innovative type of clean-burning fuel which able to be applied for a mineral diesel alternative as engines deriving out of renewable sources being with fresh either used vegetable oils as well as animal fat are mostly triglyceride-constituted (Mishra & Goswami, 2018). The key advantages of implementing biodiesel was the renewability, minimal emission rates, great flashpoint, exceptional oxidative stability and remarkable cetane number which could be generated without changing current engines (Mirhashemi & Sadrnia, 2020).

Transesterification is currently almost widely used technique of biodiesel production in which triglycerides (algae oil, vegetable oils either animal fats) react by alcohol in which most often methanol either ethanol and applying a catalyst which enhances the conversion of triglyceride into fatty acids methyl ester (FAME) as well as glycerol as a product (Musa, 2016). Methanol is the most consumed alcohol due to its minimized costs and physiochemical properties (Verma et al., 2016). The most suitable feedstock in biodiesel production are vegetable oils, as they were sustainable alongside environmentally friendly. This conceivably utilised for whether edible either non-edible oils, which edible oils

production approximately 95 percent as the total output of biodiesel, since those are extensively developed as well as give competing properties for biodiesel (Demirbas et al., 2016). Sunflower is among the world largest of oil seed product, refined for oil production (Hasanuzzaman, 2019). From a chemical reaction perspective, sunflower oil from natural sources is the leading primary raw material beneficial to biodiesel production, as the pure triglycerides conversion to fatty acid methyl ester is great with reaction time is approximately limited (Musa, 2016).

Heterogeneous catalyst have been developed as it can be efficiently separated, recycled and enhance the product purification method (Thangaraj et al., 2019). The heterogeneous catalysts based on agricultural wastes exhibited improved catalytic activity and potential to convert oils into biodiesel (Mohamed et al., 2020). The waste leaves of ginger (Zingiber Officinale) collected after cultivating the crops is among the organic compounds where the aqueous ash extract which greatly alkaline in nature and generally required for food flavour enhancer in traditional foods (Devi et al., 2017). In this case, this implied that highly complex nature of ginger leaves ash can be used for an effective heterogeneous catalyst for producing biodiesel through oil transesterification reaction. Another is for environmental consideration because it develops excess agricultural waste into valuable, beneficial materials instead of being disposed of improperly, and the other for economic purposes, which use agricultural by-products decreases the catalyst high processing expenditures (Shafy & Mansour, 2018). A lower water content and a higher percentage of non-polar compounds and ginger leaves could describe their higher biodiesel miscibility, which would provide acceptable antioxidant efficiency (Lawan et al., 2019).

According to Yari et al. (2019), energy as the leading force of any industrial production has a significant role in commercial development and growth for the result of all of a society economic activities. The human life increasing reliance on energy involve invented energy for an essential aspect in economic advancement as well as profitability (Owusu & Sarkodie, 2016). One of the approaches used to evaluate a system sustainability problems are for determine energy used as the energy generated either one kilogram of production process (Yari et al., 2019). Whereas, the accepted parameters for study of biofuel energy efficiency, the pure energy (NEG) amount as well as the variance among overall energy input and output (Naderloo et al., 2017). The energy form are categorized within two groups of renewable energy and non-renewable energy. Energy are required to produce indirect energy and those inputs applied by humans for the production process to enhance production are considered enabling energy (Yari et al., 2019).

1.2 Problem Statement

Most of the currently operating biodiesel plants are batch process plants using homogeneous catalysts. This technology faces numerous difficulties including costly downstream separation methods, the catalyst inadequacy towards low cost feedstock and the catalyst non-renewability. Although the conversion of existing homogeneous catalytic plant into heterogeneous plant has potential techno-economic benefits, there are currently no technical or experimental data to support this case. The agricultural waste of ginger leaves is generally available and yet no investigation has carried out the chemical composition along with catalytic activity in biodiesel production, as well as being part of other reactions. Hence, the characterization for the base-catalysed using ash derived from ginger leaves is investigated and biodiesel yield (%) from sunflower oil via transesterification is also conducted. The purpose of this ginger leaves for the heterogeneous base catalyst would add a new dimension in the invention of renewable and environmental friendly of sustainable raw materials. In published document, there was no analysis on the energy usage measures for biodiesel production from sunflower oil using calcined ginger leaves (CGL), KOH-activated ginger leaves (KGL), and NaOH-activated ginger leaves (NGL) catalyst. However, no previous research on assessed the economic difference resulting in various forms of heterogeneous catalytic processes for the development of biodiesel.

1.3 Research Objectives

The purpose of this research project is to accomplish the undermentioned specific objectives:

i. To characterize the leaves of ginger plant derived heterogeneous base catalyst in three different forms, calcined (CGL), activated by KOH (KGL) and activated by NaOH (NGL).

ii. To conduct the preliminary test on biodiesel yield (%) from sunflower oil via transesterification using CGL, KGL and NGL Catalyst under operating parameters of reaction time, methanol to oil ratio and catalyst load.

iii. To study the energy and economic analyses as well as cost involved in producing one unit of biodiesel from sunflower oil using different catalyst types (CGL, KGL and NGL).

- The full test rang could not be achieved due to the Movement Control Order (MCO) of Covid-19.

1.4 Scope of Study

The scope of this study is mainly focusing on the characterization of ginger leaves as a heterogeneous catalyst for assemble biodiesel from sunflower oil, the effect of the operation parameters (time reaction, methanol to oil ratio and catalyst load) was determined and carried out preliminary test on the biodiesel yield. This research will be also focused on the energy ratio, energy productivity and specific energy, as well as the value of renewable energy as in cycle of biodiesel production utilizing sunflower oil using CGL, KGL and NGL catalyst, and also economic analysis as well as expense included for producing one unit of biodiesel.

1.5 Summary

This chapter discussed the background of study of this project researches, problem statement, research objective and scope of the study. The synthesis of biodiesel is the best alternative energy to improve economy and positive economic impact which considering the rising cost of petroleum diesel nowadays. In addition, using the heterogeneous catalyst instead of homogeneous catalyst can mitigate the effects of homogeneous catalyst and develop environmentally friendly and sustainable of biodiesel. From this perspective, ginger leaves were treated with three distinct techniques which are calcination, KOH activated and NaOH activated as heterogeneous catalyst to produce biodiesel from sunflower oil and the effect of several operation parameters is discussed in this work. Energy analysis is one of the techniques by which environmental problems are analysed. A specific of the preferred indicators for analysing the energy productivity is to increase the net energy gain (NEG). Throughout all, the net energy ratio implies the pattern as the energy productivity as the output energy to input energy ratio. In this project report, characterization and biodiesel production from sunflower oil using CGL, KGL and NGL catalyst will be carried out via experiment as well as energy and economic analysis are performed intended to achieve the objective listed.