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# PRODUCTION OF BIODIESEL FROM GREEN ALGAE SPECIES BY TRANSESTERIFICATION PROCESS

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## Abstract

The research was emphasized on the production of biodiesel from the extraction of green algae; namely *Spirogyra species* (macroalgae) and *Tetraspora species* (microalgae) through the transesterification method. The biodiesel from algal oil is alternative raw material as vegetable oil that is produced from edible source. The main purpose of the research was to compare the amount of Fatty Acid Methyl Ester (FAME) produce from both sample and to determine the best method that gives the most effective result on this experiment. The methods used on this research were the effect on catalyst and the effect on homogenizer. Major findings or trends found as the result of the analysis shown that the highest percentage of esters with 36% (FAME) is at 1.0M concentration of catalyst (NaOH) while the least amount of ester is at 1.5M with 12.5% (FAME) concentration catalyst for the macro algae. The Microalgae, effect on homogenizer shows the highest amount of ester with 59% (FAME) is during 3 minutes of time while the macro algae show the highest amount of ester with 70% (FAME) is at 6 minutes for the effect on homogenizer. Transesterification of the oil to its corresponding fatty ester is the most promising solution to the high viscosity problem. Fatty acid methyl esters produced from natural oils and fats called as biodiesel. Generally, methanol has been mostly used to produce biodiesel as it is the least expensive alcohol.

Keywords: Fatty Acid Methyl Ester (FAME); *spirogyra sp.*; *tetraspora sp.*; transesterification

## 1.0 INTRODUCTION

Macroalgae was the most inexpensive resources in biodiesel production. It is increasingly gaining attention as a potential feedstock for biofuels and as an alternative fuel for aviation. (Gegg & Wells, 2017) Among biomass, algae usually have a higher photosynthetic efficiency than other biomass. Several macroalgae species are abundantly available in Sarawak and mostly the species are situated along coastline region. In addition, the climate in Sarawak is fit for algae cultivation and with this benefit, it would be easier to a produce large amount of oil for biodiesel production. Many studies have been carried out on biodiesel production from various algae species and using different esterifications process (Ahmed et al., 2010).

Microalgae represent an exceptionally diverse but highly specialized group of microorganisms adapted to various ecological habitats. Microalgae are photosynthetic microorganism that converts sunlight, water, and $CO_2$ to sugars, from which macromolecules such as lipids and triacylglycerides (TAGs) can be obtained.

The TAGs are the promising and sustainable feedstock for biodiesel production. Many microalgae have the ability to produce substantial amounts (20-50%) of triacylglycerol (TAGs) as a storage lipid under photo oxidative stress or other adverse environmental conditions. (Sakthivel et al 2011)

Microalgae can be a renewable energy source that holds a potential without an adverse effect on the supply of food and other crop products. Most of the research nowadays is focusing on the biochemical products that are using microalgae as a source of fuel (Oncel, 2013). When processed through chemical or biological reactions, microalgae can provide different types of renewable biofuels. These include biodiesel, bio hydrogen, bio ethanol and bio methane. With regard to microalgae based fuels the objective is on the biodiesel production.

Transesterification- Biodiesel is typically a mixture of fatty acid alkyl esters, obtained by transesterification (or ester exchange) of oils or fats. (Amaro et al 2012) Biodiesel, i.e., fatty acids methyl ester (FAME), is mainly produce from edible vegetable oils, animal fats, and microbial biomass. Biodiesel is routinely produced by the extraction of algal oil followed by transesterification. In comparison to any other feedstock, microalgae are more productive in oil yield for biodiesel production. Transesterification is the most familiar method and leads to monoalkyl esters of vegetable oils and fats, called bio-diesel when used for fuel purposes; the molar ratio of alcohol, catalysts, reaction temperature, reaction time parameters that effect biodiesel yield and free fatty acids and water content of oils or fats.

The aim of this study is to compare the amount of Fatty Acid Methyl Ester (FAME) produce from the sample of namely Spirogyra species (macroalgae) and Tetraspora species (microalgae).

## 2.0 EXPERIMENTAL

**Materials and Method**

Sample collection Site: The experiment was carried out in the laboratory of Chemistry Lab, Department of Engineering, Faculty of Chemical Engineering, University Technology MARA Cawangan Terengganu Campus Bukit Besi, Malaysia.

Microalgae (tetraspora) were washed and cleaned from dust, sands and other impurities. Both macro algae (spirogyra) and microalgae (tetraspora) were dried in the oven overnight, temperature at 800°C.

**A. Effect on catalyst (macro algae)**

Catalyst was prepared by calculating mass of Sodium Hydroxide, NaOH for each molarity (molarity = mass g/ volume L). NaOH was weighed for 0.05g, 0.1g, 0.15g and 0.2g for molarity 0.5M, 1.0M, 1.5M and 2.0M. NaOH was added with distilled water with V=100ml into a conical test tube (CTT).

Samples were weighed 0.1g x 4 samples. 20 ml of methanol were added into 5 conical test tubes (CTT). Samples were added to each CTT. Catalyst (NaOH mixture) was added to all 4 CTT. The samples has been centrifuged for 10 minutes at 3500-rpm speed. The sample have been taken out using microliter pipette (1 microL) and was put into vials that already contain with hexane. The vials were parafilm to prevent hexane from volatile. The data were ran using Gas chromatography–mass spectrometry (GC-MS).

**B. Effect on homogenizer**

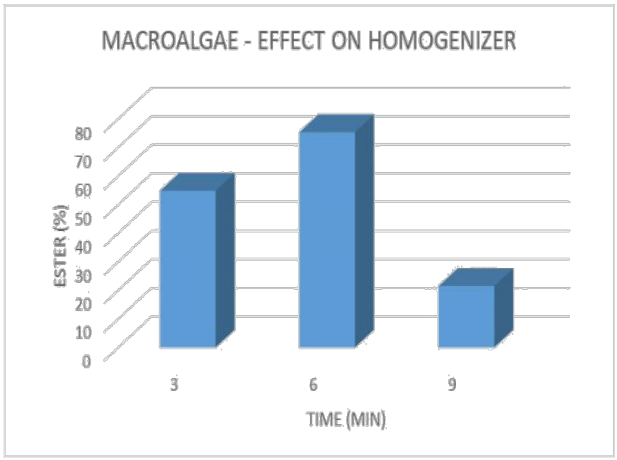
The microalgae sample was weighed at 0.1g x 4 samples. 20ml methanol was added in the conical test tube (CTT). The sample was added into the same CTT. While preparing the samples, the water bath was turned on and switch to heating mode until the temperature reached 60°C. The homogenizer blade was cleaned with methanol solution to remove impurities (contaminant). A beaker (medium size) that contain water was placed into the water bath until the water inside and outside the beaker reached the equilibrium temperature at 60°C. When the temperature reached 60°C, the conical test tube that contains a mixture of sample and methanol was homogenized based on the time labeled from (3, 6, 9, 12 min) at 10000-rpm speed. The sample was centrifuged for 10 minutes at 3500-rpm speed. The sample was taken out using microliter pipette (1 microL) and was put into a vial that already contains with hexane. The vials were parafilm to prevent hexane from volatile. The data were ran using Gas chromatography–mass spectrometry (GC-MS) machine. The same steps were repeated for macro algae samples.

## 3.0 RESULTS AND DISCUSSIONS

**Results**

**A. The Effect of Homogenizer on Biodiesel Production (Macroalgae)**

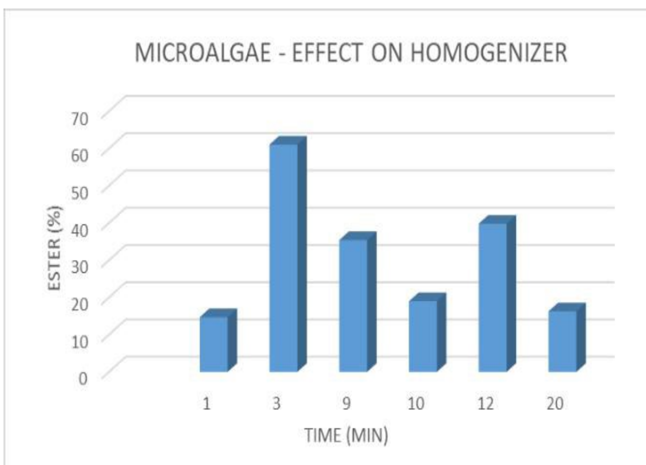
Biodiesel production can be effective by using Homogenizer in terms of their efficacy. For Macroalgae, the maximum biodiesel yield as 70% was obtained at 10000 rpm as the speed of rotation in 6 minutes. The least biodiesel yield as 17% was obtained as the speed rotation in 9 minutes as shown in graph 1.




Graph 1: Effect of homogenizer on biodiesel production (Macroalgae)

**B. The Effect of Homogenizer on Biodiesel Production (Microalgae)**

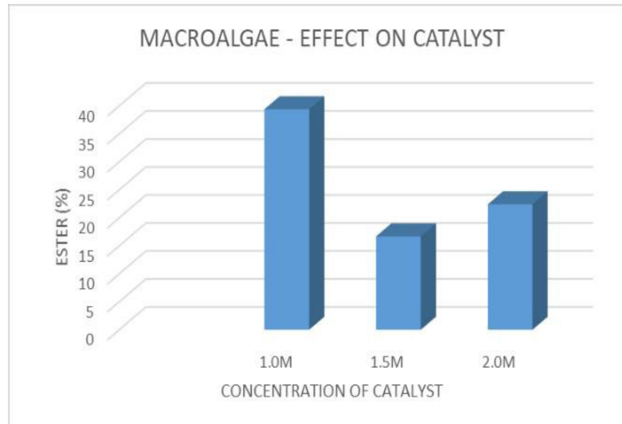
Biodiesel production can be effective by using Homogenizer in terms of their efficiency. For Microalgae, the maximum biodiesel yield as 59% was obtained at 10000 rpm as the speed of rotation in 3 minutes. The least biodiesel yield as 11% was obtained as the speed rotation in 1 minute as shown in graph 2.




Graph 2: Effect of homogenizer on biodiesel production (Microalgae)

**C. The Effect Of Catalyst Concentrations On Biodiesel Production**

Biodiesel production can be affected by the amount of catalyst used in the reactions. In this experiment, different concentrations of NaOH like 1.0M, 1.5M and 2.0M were used. The graph below shows biodiesel yield using different concentrations of NaOH as a catalyst. From the results, the optimum yield of biodiesel can be obtained at 1.0M of NaOH concentration. It reached 36 % of the biodiesel yield. The percentage decrease during 1.5M because it affected by saponification. The result shown in graph 3 (A.B.M & Aishah, 2008).




Graph 3: The effect of catalyst concentrations on biodiesel production

**Discussions**

Production of alternative fuel has attracted wide attention during the past few years, due to the diminishing petroleum reserves and environmental consequences of exhaust gases from fossil diesel. In this context, biodiesel, which is characterized as a renewable, biodegradable, and environment-friendly fuel is becoming a blooming area of high concern. Biodiesel can be produced from macro algae because it contains considerable amount of lipid contents (Hossain et al., 2008). In addition to heterotrophic, the condition lipid content can be more in algae (Oncel, 2013; Ramaraj, 2016) investigated that lipids of some macro algae (seaweeds) was reported to be very high, up to 51% of total fatty acids.

The majority of biodiesel today is produced by alkali catalyzed (e.g., NaOH, KOH) transesterification with methanol, which results in a relatively short reaction time (Freedman et al., 1984). Vasudevan & Briggs (2008), examined different biodiesel sources (edible and nonedible), virgin oil versus waste oil, algae-based biodiesel that is gaining increasing importance, the role of different catalysts including enzyme catalysts, and the current state-of-the-art in biodiesel production.

Macroalgae – Effect on catalyst – the bar graph shows that the highest amount of esters (%) is at 1.0M concentration of catalyst (NaOH). The least amount of ester is at 1.5M concentration catalyst. The effect of different concentrations of catalyst on biodiesel yield Based on results that obtained, we found that 1.0M of NaOH gave the best yield on biodiesel production among 1.0M, 1.5M and 2.0M. Fatty acid methyl ester yield increasing with the concentration of catalyst increased by 1.0%. Beyond that value, the fatty ester yield started to drop. Commonly, the increasing of catalyst concentration, it will help to fasten the reaction and gave better yield (Lam and Lee, 2013).

However, every reaction got its optimum catalyst concentration value. Beyond that value, excessive catalyst, for example NaOH will participate in saponification which reacts with triglyceride to form soap and water. Hence, it will reduce the biodiesel yield.(Hossain & Mazen, 2010)

Microalgae – Effect on homogenizer – The highest amount of ester (%) is during 3 minutes of time. The amount of ester (%) during 9 minutes to 10 minutes is decreasing rapidly. However, there are slightly increased in the amount of ester (%) during 12 minutes and decrease at 20 minutes. The optimum time with the highest biodiesel yield is at 3 minutes. Thus, the result is affected by the time. (Venkateswarulu et al 2012).

Macro algae – Effect on homogenizer – The highest amount of ester (%) is at 6 minute period of time with 75.37% ester and the least amount of ester (%) is at 9 minutes with 21.52% ester. The optimum time with the highest biodiesel yield when it reaches 6 minutes. Thus, the result was affected by the time with a different type of algae since Macro algae produce better yields compared to Microalgae based on percentage of ester. (Samarasinghe et al., 2012)

## 4.0 CONCLUSIONS

The results proved that biodiesel can be produced from microalgae/macro algae. By this way algae can be used as renewable energy. The highest percentage of biodiesel yield is Macro algae on the effect of Homogenizer with 72% of ester while the least percentage of biodiesel yield is Microalgae on the effect of homogenizer during 1 min with 11% of ester. Our results newly highlighted by producing biodiesel from macro algae though it contains lower lipid content. It can be concluded from this study that high speed homogenizer can be used as an alternate cavitation device to efficiently produce biodiesel on optimum time.

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