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Alcoholysis of Algae Oil to Produce Biodiesel

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Abstract:- A technically and financially viable solution to the numerous issues associated with fuel scarcity and high cost is biodiesel. Algae biofuels represent a highly promising alternative approach to energy generation. Microalgae have been proposed as a viable alternative for fuel production due to high oil content in their cells, making them suited for development as a material source for biodiesel manufacturing. This study used dry green algae mass (Chlorophyceae) that was grounded into a smooth powder which was obtained from Delta state. A total of 100g of powder were measured.

Algae oil extraction was done using lipid extraction. Additionally, acid esterification was the first step in the characterization of biodiesel. Using a standard solution of 1.0M NaOH solution, the acid value of the reaction mixture was measured using a standard acid base titration method. The results showed that the acid value was 0.280%, the iodine value was 128.592 mg/l, the specific gravity was 0.8103, the density was 0.8099 g/ml, the refractive index was read off as 1.41, the cloud points were -50C, the smokes were 244^{0}C, and the flashes were likewise 288oC.

Using USA-based Buck Scientific M530, the analysis method employed was FTIR, and FTIR spectra were co-added at 32 scans with a resolution of 4 cm^{-1}. The spectra were collected at frequency areas of 4,000 – 600 cm^{-1}. Transmitter values representing FTIR spectra were shown. Trans esterification is the technique used to turn algae oil into biodiesel. This was carried out in a round-bottom flask with a magnetic stirrer and condenser using catalyst that was supplied (three percent weight of the oil). Curves that are analytical were created. The determination of the diglycerides and triglycerides was made possible by the analytical curves from diolein and triolein. After the product was dried at 80^{0}C in a vacuum evaporator, a clear and pure biodiesel was obtained.

I. INTRODUCTION

The need to find a substitute fuel has grown due to factors like environmental concerns, rising oil prices, and reliance on foreign oil. The sustainable alternative energy source that garners the most attention in the present situation is biodiesel, owing to its advantageous characteristics including being easily biodegradable and ecologically beneficial. Oil obtained from algae is a renewable resource alternative to petroleum fuels, natural gas, and petroleum. Also, biodiesel derived from oil crops is a possible renewable and carbon neutral fuel (6, and 8). However, renewable oils are not a strong rival to petroleum fuels because of their high price and scarce availability.

The use of vegetable oils gained popularity in the early 1980s due to concerns about the environment, energy security. Since there is overproduction in agriculture, trans esterification was found to be the most effective way to produce vegetable oils in place of petroleum fuels, as the latter became more expensive and less abundant. Investors and consumers started to find biodiesel becoming more attractive (21, 15).

In the early 1990s, Martin Mittelbach was a member of a group of pioneering researchers that worked on the creation of the biodiesel fuel industry in Europe and South Africa; with the U.S. industry developed more slowly (17, 16). In 1996, Pacific Biodiesel manufacturing production facility on the Hawaiian island of Miami to convert re-used cooking oil into biodiesel, become one of the first biodiesel facilities in the United States due to decreased pricing for petroleum fuel. (14, 9).

The Environmental Protection Agency (E.P.A.) estimated that algae is the only type of biofuel modelled to date. Fatty acid methyl trans-esterification can reduce greenhouse gas emissions by more than 60 percent when compared to petroleum diesel (19, 20). While using microalgae as a fuel source is not a novel idea, the rising costs of diesel and the effects of global warming have recently propelled this solution to the top [2, 7].

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Chemistry classes in high school can be tedious and challenging. However, if students perceive a means to alter the world, that tedious and difficult laboratory work in chemistry may become an interesting and fun subject. A technically and financially viable solution to the numerous issues associated with expensive gasoline and shortage is biodiesel. Because microalgae cells contain a lot of oil, they can be used as a material source for the manufacturing of biodiesel (13, 11). This prompted the researchers to investigate these procedures and turn algae mass into biodiesel. Students would gain knowledge of the procedures used to produce biodiesel from algae mass and be better equipped to propose solutions to the high cost and limited availability of fuel in the future.

II. LITERATURE

Studies have demonstrated that switching to biodiesel from petroleum fuel lowers greenhouse gas emissions by more than 76%. Since civilization developed so quickly, there has been an increase in the usage of fossil fuels, which has decreased the reserves of these resources and severely harmed the environment (14, 19). The development of new renewable energy sources to displace fossil fuels is urgently needed in order for international efforts to attain carbon neutrality (12, 19).

An innovative and environmentally friendly substitute for diesel fuel is biodiesel, which is made from renewable resources like vegetable or animal fat. Esters produced by ethanol or methanol and long-chain saturated as well as unsaturated fatty acids, including palmitic acid, stearic acid, oleic acid, and linoleic acid, constitute the vast majority of this renewable resource (20, 15). As a result, researchers and developers of biodiesel have drawn interest from academics all around the world.

As a result, the most viable substitute for fossil fuels is microalgae. Lipid found in microalgae, or the microalgae cell itself, can be used to generate liquid fuels like ethanol and liquid hydrocarbon fuels, as well as gaseous fuels like hydrogen and biogas (10, 8). Thus, the current stage of the development of microalgae biomass energy comprises the generation of methane through anaerobic digestion (3, 7), the synthesis of biodiesel from microalgae lipid through transesterification (21, 4), and the production of hydrocarbons or substances resembling crude oil through gasification and pyrolysis (9, 17).

III. METHODOLOGY

Dry green algae (*Chlorophyceae*) were used in this research which was obtained in Delta state. Every chemical used for reagents and solvents was purchased from a commercial supplier, and care has been taken to adhere to analytical grade specifications. Dry algae were grinded into a smooth powder by a small grinding machine for 1hr.30 minutes which weighed 100g.

Weighed sample was extracted using 500ml n-hexane in a soxhlet extractor (UNE-EN 734-1, 2006) for 5 hours. The extracted oil was placed in water bath at low temperature to evaporate the n-hexane from the extract. Extracted algae oil was weighed and stored in an air tight jar to avoid oxidation. Lipid yield was calculated with this equation:

$$\%Lipid = \frac{\text{Mass of Lipid}}{\text{Mass of sample}} \times 100$$

$$\%Lipid = \frac{\text{Mass of Lipid (g)}}{Mass\ of\ microalgea\ (g)} \times 100$$

An analysis was done on the extracted oil's fatty acid profile using a Buck Scientific M530 USA FTIR. The spectra were obtained and modified using the Gram A1 software.. Samples weighing around 1.0 g were added, along with 0.5 ml of nujol, and thoroughly mixed before being put on the salt pellet.

A. Determination of Fatty Acid (Acid Value)

➢ *Procedure*

Distilled alcohol (25 ml), phenolphthalein (1 %), and 25 ml of diethyl ether were combined, and carefully neutralized with 0.1 M NaOH. 1 - 10 g of oil or melted fat were dissolved in a mixed neutral solvent, and the mixture was titrated with aqueous 0.1M NaOH while being continuously shaken to produce a pink colour which persisted for a period of fifteen seconds.

B. Specific Gravity

➢ *Procedure:*

After a thorough cleaning with detergent, water, and petroleum ether, the 50ml pycometer container was dried and weighed. Water was put into the bottle, weighed, and sealed. After the bottle was once more dried, the oil sample was added, and it was weighed.

C. Refractive Index (RI)

➢ *Procedure:*

Using a light compensator, the Abbe refract meter was reset. The oil sample was seared on the lower prism of the instrument and was closed. Light was passed by means of the bungled mirror; the reflected light appeared in form of a dark background. Fine adjustment was used to move the telescope tubes until the black shadow appears central in the cross-wire indicator.

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D. Determination of Iodine Value

➢ *Procedure:*

Oil was poured into a small beaker, small rod was inserted, then suitable quantity of the sample was weighed out of the oil into a dry glass -stoppered bottle of about 250ml capacity. The approximate weight in g of the oil was taken and was calculated using 20 to divide the highest expected iodine value. 10ml of carbon tetrachloride was added to the oil or melted fat and dissolved.

Also, 20ml of wijis' solution was added, the stopper (previously moistened with potassium iodine solution) was added and allowed to stand in the dark for 30 minutes. Also, 15ml of potassium iodine solution (10%) and 100ml water was added, mixed and titrated with 0.1M thiosulphate solution, starch was used as indicator just before the end-point (titration = aml). A blank was carried out at the same time which commenced with 10ml of carbon tetrachloride (titration = bml).

IV. RESULTS

Table 1 Analysis of Algae Oil from Extraction.

Parameters	Oil of Algae
Acid value %	0.70 x 5.61 2.199 = 1.786%
Free fatty acid %	2FFA = Acid Value FFA = acid value/2 = 1.786 2 = 0.893
Specific gravity	Wt of flask +oil – wt of flask Wt of equal volume of water = 106.497 – 89.173 20 = 0.8662
Iodine value	(19.8 – 7.5) – 1.269 0.3 = 52.029
Melting point O C	6.0
Refractive index	1.42

Table 2: Characterization Compared with Global Standard

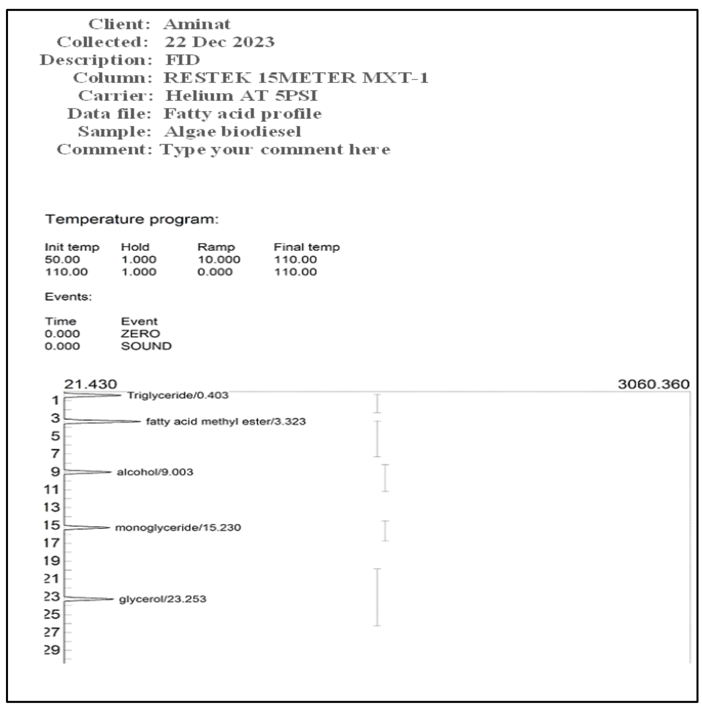
Properties	Units	Chlorophyceae	ASTM D6584-08
Acid value	KOH/g	.560	.8 max
FFA	%	0.280	--
Refractive index	--	1.41	--
Specific gravity (28°C)	g/ml	.81	.88
Density	g/ml	0.8099	-
Iodine value	mg/l	128.592	120

Trans-esterification process was adopted to convert the extracted algal oil into biodiesel. A catalyst weighed 3% of the oil was placed in a rotund bottomed flask having the condenser and magnetic stirrer. The reaction took 1 hr. to complete at 60℃. The proportion of oil to methanol was 10:1. After the trans-esterification procedure, the combination of methyl ester and glycerin \was left in a separating funnel for them to be separated for 16 hours.

Two layers were formed after the 16 hours, with biodiesel at the top layer and glycerin as bottom of the funnel. Glycerin layer was drained out of the funnel and the biodiesel was left. Hot water was spewed on the biodiesel to remove the soluble components which settled down at the bottom of the funnel. A vacuum evaporator at 80 0 C was used to dry the impure biodiesel in order to achieve a very clear and pure biodiesel.

Table 3: Measurement and Determination of Glycerol (Free and Total), Triglycerides and Fatty Acid Methyl Esther of Biodiesel According to ASTM D6584-08 Standard

Parameters	Algae biodiesel	
	Ppm	% components
Triglyceride	0.7933	2.776
Alcohol	1.2082	4.228
Fatty Acid Methyl Ester	22.7882	79.737
Monoglyceride	0.9882	3.458
Glycerol	2.0994	7.346



Graph 1: Analytical Curves of Diolein and Triolein showing Both Diglycerides and Triglycerides Determination.

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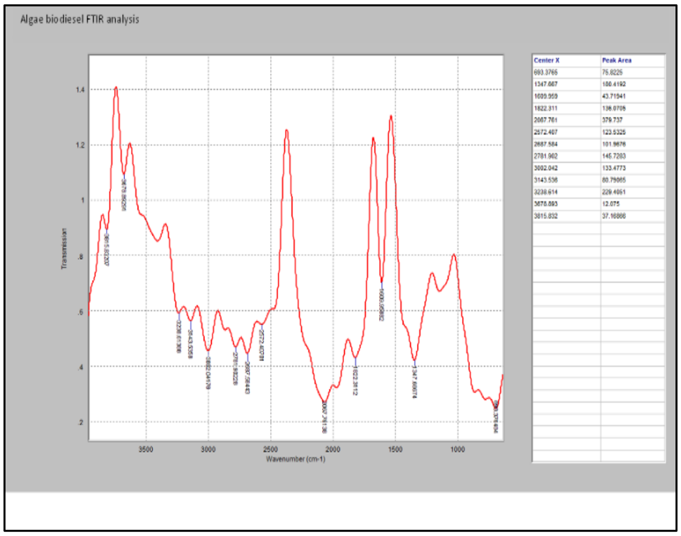

Graph 2 FTIR Curve To Assess Biodiesel Quality Using ASTM D6584.

V. CONCLUSION

One hundred grams of Chlorophyceae algal biomass were used to manufacture biodiesel in this research, the extracted algae oil was minimal and well-characterized. Biodiesel was created by the tran sesterification process. After then, left for 16 hours to separate from the glycerin. Every process was carefully thought out and carried out.

There is now a means for students to learn each stage of the small-scale biodiesel production process. The students gained an understanding of a variety of chemistry concepts, such as chemical processes, equations, equilibrium, and solubility.

RECOMMENDATIONS

More investigation is needed into the creative methods for gathering and separating microalgae biomass. The somatic collection method, which is popular for extracting water from large volumes of microalga suspension, requires a significant amount of time and energy. Since algal biomass bio refinery has only been implemented locally, more research is required to create a new manufacturing process with large-scale, widely applicable chemical applications that will benefit everyone.

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