PRODUCTION OF BIODIESEL FROM NATURAL ALGAE

Mr. RAVI PRAJAPATI[a] , Mr.NITESH BARAIYA[b]

[a]Department of industrial chemistry, Parul Institute of Applied Science, Parul University,
Vadodara-391760,INDIA

[b]Department of chemical engineering, Parul Institute of Technology, Parul University,
Vadodara-391760,INDIA.

Abstract:Due to its advantages for the environment and utilization of renewable resources, biodiesel has recently gained in popularity. The globe is continuously modernizing and industrializing. As a result, the number of vehicles and engines is rising. However, the energy sources utilized in these engines are finite and steadily dwindling. The need for an alternative fuel for diesel engines results from this circumstance. Another fuel option for diesel engines is biodiesel. Biodiesel is made from the esters of animal and vegetable fats. In this essay, the potential for producing biodiesel from algae oil was covered. Algae are often small organisms that are considered of as basic aquatic plants because they lack leaves, roots, and stems. They also reproduce similarly to primates. Both freshwater and oceanic waters include aquatic algae. The size of these organisms ranges from enormous kelp (meters in length) to those scarcely detectable under a microscope. The size, shape, and growth form of algae vary widely. With various species, the algae contain 2-65% oil. The well-known transesterification technique was used in this study to turn the oil into biodiesel

KEYWORDS:Algae, Natural Algae, Methanol, NaOH, KOH, n-Hexane, Transesretification, Biodiesel.

1.) Introduction

One of the most crucial elements in the effort to reduce greenhouse gas emissions and replace fossil fuels is bioenergy. As industrialization and population grow, so does the need for energy. Petroleum, natural gas, coal, hydropower, and nuclear energy are the principal energy sources. The main drawback of using petroleum-based fuels is the air pollution that petroleum diesel produces. A significant source of greenhouse gas is the combustion of petroleum-based fuel (GHG)[1]. In addition to these emissions, petroleum diesel is a significant producer of other air pollutants, such as NOx, SOx, CO, particulate matter, and volatile organic compounds. One of the better sources of energy is biomass. Introduction of biomass energy on a large scale could support sustainable development on social, economic, and environmental fronts[2]. One such alternative fuel is biodiesel, which is produced when triglyceride oil is transesterification with monohydric alcohols. In addition to providing a growth environment for microalgae, waste effluents treatment is a possible option because the nutrients for microalgae production (mostly nitrogen and phosphorus) may be derived from liquid effluent wastes[3]. The physical and chemical characteristics of biodiesel made from algal oil are comparable to those of diesel made from petroleum, biodiesel made from first-generation crops, and the international biodiesel standard for cars[4]. It has long been known that biodiesel made from canola, soybean, palm, sunflower, and algal oil may replace diesel fuel[5]. An alternative fuel made from renewable resources, biodiesel is harmless and biodegradable. Waste cooking oil such as palm, soybean, canola, rice bran, sunflower, coconut, corn oil, fish oil, chicken fat, and algae can be used to make biodiesel fuel, which would help to reduce our dependence on petroleum-based fuel. Global warming is being brought on by the massive increase in CO2 levels in the atmosphere brought on by the burning of fossil fuels[6]. Biomass has received attention as an alternative energy source because it is a renewable resource and because it uses photosynthesis to reduce atmospheric CO2. Because the CO2 emitted by the burning of biomass is offset by the CO2 fixed by photosynthesis, prolonged biomass growth has no effect on the atmospheric CO2 equilibrium. In comparison to other biomass, algae (both macro and microalgae) often have a higher photosynthetic efficiency[7].

2.) Methods Of Production

2.1) Site:-

This experiment was carried out in laboratory of chemical engineering department, institute of engineering technology ,faculty of engineering department, Parul University, vadodara, Gujrat, India.

2.2) Sample collection:-

The algae is collected from two sports first from near to lotus pond and the another one is surrounding the well

Fig.1: sample collection

fig.2: sample collection

2.3) Oil Extraction:-

A two types of methods are use for oil extraction from algae,

1) Chemical Method
2) Physical Method

1.)Chemical Method :-

The dry algae was first mixed with a hexane and ether solution in the chemical procedure, and the combination was then allowed to sit for 24 hours to settle. The biomass was collected and weighed after the solution had been filtered for 24 hours. Utilizing an evaporator, the extracted oil was evaporated in a vacuum to release hexane and ether solution.

The another method which is use for extraction of oil from algae is soxhlet extraction method.

2.) Physical Method :-

Algae can have their oil extracted using a mechanical press. Up to 70% of the algal oil can be extracted using this method, which drives the algal paste into a nozzle that extracts the oil and expel much drier biomass. However, this method typically needs a dry algae feedstock. Algae is dry by dewatering via sunlight or oven.The ground algae were dried in sunlight at 3-4 days for releasing water. The algae which we take for the production of biodiesel its scientific name is Brittanica. After that due to soxhlet extractor we extract the oil from dry algae with the help of n-hexane as solvent.

Fig.3 Fig.4 Fig.5 Fig.6

(extraction of algaloil from algae by using soxhlet extractor)

First make a thimble of filterpaper after that put the dry algae in the thimble, after that put that thimble into the soxhlet apparatus, set the soxhlet apparatus on Round Bottom Flask. After that set the condenser on the soxhlet apparatus. After that heating the RBF so that sovent(n-Hexane) which is present in RBF is evaporated, after that its vapor was went to condenser. Due to condenser its converted into liquid and drop into the soxhlet apparatus at there we put the thimble of dry algae. Due to this the oil which was present in algae is transferred into solvent. After that when the soxhlet apparatus was completely filled with the solvent then pressure was generated in the apparatus and due to that pressure the whole sovent and oil was came in the RBF.

2.4) Evaporation:-

After the 6 cycles in Soxhlet apparatus, the oil which was present in algae is transferred into solvent ,now cool the soxhlet apparatus at room temperature, after that remove the thimble from the apparatus and further apply heat so that the solvent is again evaporated and transferred into soxhlet apparatus and we got the oil in the RBF.


Fig.7 (oil + solvent) **Fig.8 (Algaloil)**

2.5) FFA calculation (Free Fatty Acid):-

Fig.8 **Fig.9**

(free fatty acid titration)

- **Calculation:-**

sample weight = 10ml
Normality of NaOH = 0.1N
Volume of NaOH Solution = initial burette reading – final burette reading
=2 – 0
=2
Molecular weight of NaOH = 40.001mol
Acid value = 40.001*0.1*2
=0.800
That is <2

2.6) Mixing of catalyst and methanol:-

0.25gm NaOH was mixed with 24 ml methanol and stirred properly for 20 min at 340 rpm.

Fig.9 **Fig.10**

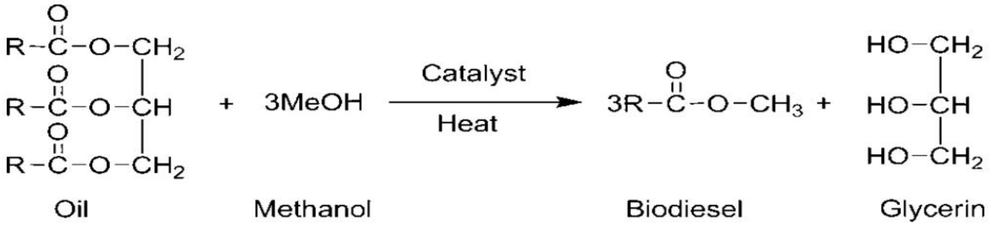
(mixing NaOH and methanol on magnetic stirrer)

If FFA content is less than 2% then we can directly do transesterification but if the FFA content is greater than 2% then first do esterification and then do transesterification.

2.7) Transesterification:-

Biodiesel is frequently produced using a process called transesterification, in which an alcohol-containing alkyl group replaces the ester molecule. Triglyceride transesterification using alcohol and a catalyst is a method for creating biodiesel. Mono- and diglycerides are the byproducts of this process, which happens in stages. The overall cost of manufacturing may be efficiently reduced to 60–70% by using inexpensive feedstock for biodiesel synthesis. This study's main goal was to examine how raw materials' impacts on transesterification were impacted by production rate, yield, and other factors. This article outlines the ideal circumstances for producing biodiesel. Because KOH dissolved with ethanol much more quickly than other catalysts like NaOH and because KOH-based glycerin is relatively manageable, it was chosen as the catalyst for transesterification. The chemical process that transforms triglycerides and alcohol into alkyl esters with the aid of a catalyst and involves swapping the R group of the alcohol for the R' group of the ester.

Factor affecting the trans esterification process are temperature, reaction time, methanol to oil molar ratio, type and amount of catalyst, mixing intensity, FFA and moisture content.The mixture of catalyst and methanol was poured into the algal oil in a conical flask. The conical flask containing solution was shaken for 3hr by magnetic stirrer at 300 rpm, the reaction process is called transesterification.



2.8) Settling:-

To clearly settle the biodiesel and sediment layers, the solution was let to stand after 16 hours of shaking.

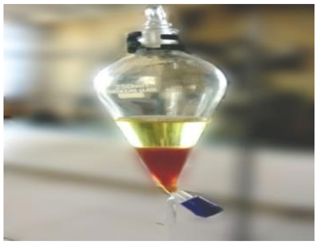


Fig.11(biodiesel + gleserol)

2.9) Biodiesel separation:-

Using a flask separator, the biodiesel was carefully separated from the sedimentation, Sediment (glycerine, pigments, etc.) quantity was calculated.

2.10) Remove micro-impurities

5% water was used to wash the biodiesel until it became clean.

2.11) Filtration:-

Filter the prepared biodiesel to remove impurities, after the filtration we got pure biodiesel which is ready to check its parameters.

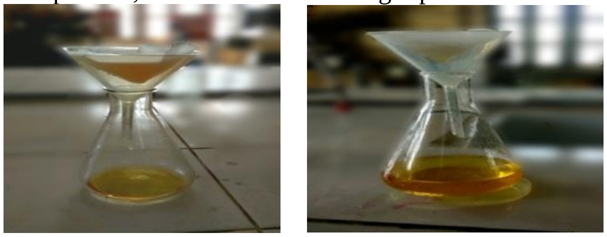


Fig.12 **Fig.13**

(Filtering biodiesel)

3.)Analysis:-

the properties of the biodiesel, including its pH, density, flash point, pour point, fire point, ash content, and cetane number, were measured after the quantity of the fuel was determined using a measuring cylinder.

3.1.1) Flash Point:-

Flash point is the lowest temperature at which a liquid emits enough vapour in a test vessel to combine with the air around to ignite and produce an ignitable combination.

Flash point is measure by using pensky martens apparatus.The purpose of the brass oil cup is to heat petroleum products to the flash point. Inside, it has markings all throughout to indicate the proper level of liquid. The lower portion of the cup is within the Air Bath or Heating Vessel, and it has a flange that sits on the brass top. Brass spacers are used to attach the top plate to the Air Bath, creating an air gap between them that allows hot air to transmit to the cup nearly totally. To ensure proper installation on the Top Plate, the cup flange contains an indication. The heat is generated by an electric heater maintained underneath the air bath, and the control of The energy regulator controls the heat. The Air Bath and the Top Plate have the purpose of keeping outside air draughts from interfering with the heating.Brass plate makes up the lid's actual cover, and it features a tubular fitting that allows it to rest on the cup. Figure shows an illustration of the actual cover. It features one circular hole that carries a split tube for accepting a brass collar of a thermometer, three peripheral holes (B, A, and C), three central holes that admit stirrer rods, and three peripheral holes (C, A, and B). The flame exposure to the oil being tested is provided through the bigger peripheral hole A. A blazing gas jet from a gas reserve installed near to hole A creates the flame. Gas mains provide the gas supply. The shutter is a metal disc that is centred on the cover's actual surface. It features two peripheral holes that line up with holes b and A on the cover's actual surface. The spring-loaded handle G, which is located on the cover itself, may rotate the shutter

Fig.14
(Pensky martens apparatus)

3.2) Viscosity:-

- Procedure:-

(1) Make sure the orifice tube is clean and the cylindrical oil cup is clear of debris.
(2) Use a ball valve to seal the opening.
(3) Set the 50 ml flask down below the Orifice's aperture.
(4) Fill the cylindrical oil cup with oil until it reaches the mark on the cup.
(5) Fill the water bath to the top.
(6) Place the thermometers in the appropriate locations to gauge the temperatures of the oil and water baths.
(7) Maintain a consistent temperature by heating the water bath, stirring the water bath, and heating the.
(8) Note the duration in seconds required to collect 50 ml of oil in the 50 ml flask after raising the bal valve at a specific temperature.
(9) Raise the temperature, perform steps 8 and 9, and record the Redwood seconds for various temperatures.

Fig.15
(Redwood viscometer)

Calculation:-

Sr.no	Temperature(°C)	Time(second)	Volume(ml)
1.	50°C	145 sec	30ml
2.	70°C	110 sec	30ml

ɣ1 = [0.0026t + 1.95/t] × specific gravity of the sample (if time is up to 100 sec)
ɣ2 = [0.0022t – 1.6/t] × specific gravity of the sample (if time is more than 100 sec)
we use second equation because our time is more than 100 sec.

1.) ɣ2 = [0.0022 t – 1.6/t] × specific gravity of the biodiesel
= [0.0022 × 145 – 1.6/145] × 0.86
=0.308 ×0.86
=0.264centipoise

2.) ɣ2 = [0.0022 t – 1.6/t] × specific gravity of the biodiesel
= [0.0022 × 145 – 1.6/145] × 0.86
=(0.242 – 0.0145) × 0.823
=0.2275 × 0.86
=0.195centipoise

Temperature	Time	viscosity
50C	145 sec	0.264centipoise
70C	110 sec	0.195centipoise

3.3) Fire point:-

The lowest temperature at which a flammable liquid still burns in the air after its fumes have been ignited.

- Procedure:-

1.) Before the test is conducted, the cup’s components are all carefully cleaned and dried.

2.)The biodiesel is poured into the cup till a certain point. To create a closed system, the lid is positioned on top of the cup. Everything, including the thermometer, is fixed properly, even the attachments.

3.) After that, the heated biodiesel sample. A 4mm diameter bed size is achieved by lighting and adjusting the test flame. At a rate of 5°C to 6°C per minute, the sample is heated. At a pace of around 60 revolutions per minute, the sample is stirred while it is being heated.

4.) Depending on the anticipated flash and fire points, the test flame is applied intermittently, and the corresponding temperatures at which the material exhibits flash and fire are documented. Depending on the grades of biodiesel materials, volatiles are excluded at high temperatures. And because it is extremely dangerous for these volatile substances to catch fire, it is crucial to specify this temperature for each biodiesel grade. The temperature at which bitumen vapour briefly catches fire in the form of a flash under certain test conditions is known as the flash point, according to BIS.

The lowest temperature under certain test circumstances at which biodiesel material ignites and burns is known as the fire point.

Fig.16
(pensky martens apparatus)

3.4) Smoke Point :-

- Procedure:-

1.)Soak a wick that has been removed and dried for about 125 mm in the sample (biodiesel). Incorporate it into the candle's wick tube.
2.)Add a wick to the sample container and fill it with the necessary amount of liquid (20 ml).
3.)Remove the wick horizontally (6 mm) from the candle's end.
4.)Insert this assembly into the appliance's combustion chamber.
5.)Open the glass door, light the candle, and tuck the wick in (The flame should be about 10mm height). Burn the lamp for five minutes.
6.)Raise the candle until the chimney starts to smoke .
7.)Burn the candle slowly until the smoke disappears.

Fig.17 **Fig.18**
(Smoke point appratrus)

3.5) Specific gravity:-

- Procedure :-

1.) Take clean and dry gravity bottle after that take weight of empty gravity bottle with the help of weight machine.
2.) now take distilled water in one beaker after that fill the distilled water into dry and clean empty gravity bottle ,and take a weight with the help of digital weight balance.
3.) Now remove the distilled water from the bottle make the bottle dry after that fill the liquid sample (biodiesel) in the bottle, and take a weight with the help of digital weight machine.
4.) Now calculate the mass of the liquid sample and water, because of this minus the weight of empty specific gravity bottle from the weight of distilled water and weight of liquid sample. So that we got the mass of liquid sample and water.
5.) Now divide the mass of liquid sample by mass of distilled water so at the end we got specific gravity.

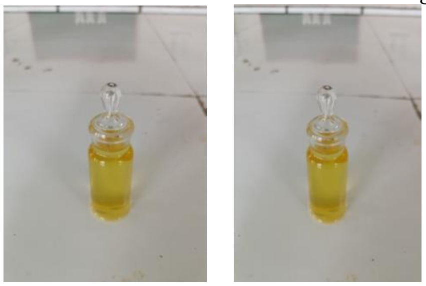


Fig.19 **Fig.20**
(Gravity bottel)

- Calculations:-

Weight of empty gravity bottle (w1) = 21.54gm
Specific gravity bottle + Distilled water (W2) = 55.58gm
Specific gravity bottle + biodiesel (W3) = 50.39gm

Mass of the liquid sample(biodisel) = W3 - W1 = 50.39 – 21.54
= 28.85
Mass of Distilled water = W2 –W1 = 55.58 – 21.54
=34.04
Specific gravity of liquid sample (biodiesel) = Mass of the liquid sample / Mass of equal volume of water
=28.85/34.04
=0.84
Specific gravity of biodiesel = 0.84
Specific gravity is unit less because it’s a ratio of density of liquid divided by density of distilled water.

3.6) Density :-

If we want to find Density of liquid sample then the specific gravity of that particular sample is multiplied by density of water. Density is the measure of mass per unit volume at specified temperature and pressure. Its denoted by “ρ**”.**
Density of water at room temperature = 0.997gm/ml
Specific gravity of biodiesel = 0.84
Specific gravity of liquid sample = density of liquid sample / density of distilled water
Density of liquid sample = specific gravity of liquid sample × density of distilled water

= 0.84 × 0.997
= 0.83 gm/ml
Density of biodiesel =0.83 gm/ml

4.)Result:-

Comparison of Biodiesel parameters with Indian Standard:-

Parameters	**Algal biodiesel**	**Indian standard**
Density	0.83gm/ml	0.73gm/ml
Flash point	98°C	120°C
Fire point	125°C	150°C
Viscosity	2.64 cSt	3.6 to 5.0 cSt
Smoke point	40°C	45-55°C
Specific gravity	0.84	0.88

5.) Conclusion:-

Algae technology is exceptional in its capacity to convert waste CO2 into a useful product. By converting leftover CO2 from power plants into a clean fuel called biodiesel, algae increase the amount of energy we can use from the combustion of coal while lowering carbon emissions. Regardless of the condition with the light, algae reduce NOx day and night. Due to the substantially higher productivity of algae, the production of biodiesel from them takes place in a closed system, or photo-bioreactor.
Photo-bioreactors offer regulated environments that can adjust to the needs of highly productive microalgae to enable year-round output. The prevention of contamination in open air production designs needs more study.Algal biodiesel manufacturing in the past has demonstrated potential. Prices for fossil fuels have doubled in the last ten years, which opens the door for various alternative fuels. However, for the time being, the price of biodiesel made from algae cannot match that of regular fuel. The cost of biodiesel would be more tolerable with additional technological advancements in the production process.Research into the fundamental biology of microalgae, species choice, genetic modification, and the metabolic switch for carbon sequestration are also important to make the large-scale production of algae habitable.

6.) References

1.) Goldemberg, J., 2000. World Energy Assessment, Preface.United Nations Development Programme, new York, NY, USA.
2.)Kulkarni, M.G. and A.K. Dalai, 2006. Waste cooking iol-an economical source for biodiesel: A review. Ind. Eng. Chem. Res., 45: 2901-2913.
3. Klass, L.D., 1998. Biomass for Renewable Energy, Fuels and Chemicals, Academic Press, New York, pp: 1-2.
4. Turkenburg, W.C., 2000. Renewable energy technologies. In: Goldemberg, J. (Ed). World Energy Assessment, Preface. United Nations Development Programme, New York, USA, pp: 219-272.
5. Lang, X., A.K. Dalai, N.N. Bakhshi, M.J. Reaney and P.B. Hertz, 2002. Preparation and characterization of biodiesels from various BioOils. Bioresour. Technol., 80: 53-62.
6. Spolaore, P., C. Joannis-Cassan, E. Duran and A. Isambert, 2006. Commercial applications of microalgae. J. Biosci. Bioeng., 101: 87-96.
7. Sharif, A.B.M.H, A.B. Nasrulhaq, H.A.M., Majid, S. Chandran and R. Zuliana, 2007. Biodiesel production from waste cooking oil as environmental benefits and recycling process. A Review. Asia Biofuel Conference Book. Dec. 11-13. Singapore.
8. Hall, D.O., H.E. Mynick and R.H. Williams, 1991. Cooling the greenhouse with bioenergy. Nature, 353: 11.
9. Macedo, I.D.C., 199. Energy from biomass and wastes. Biomass Bioenergy, 3: 77-80.
10. Shay, E.G., 1993. Diesel fuel from vegetable oils: Status and Opportunities. Biomass Bioenergy, 4: 227-242.
11. Thomas, F.R., 2006. Algae for liquid fuel production Oakhaven Permaculture center. Retrieved on 2006-12-18. Permaculture Activist, 59: 1-2.
12. Roessler, P.G., L.M. Brown, T.G. Dunahay, D.A. Heacox, E.E. Jarvis and J.C. Schneider, 1994. Genetic-engineering approaches for enhanced production of biodiesel fuel from microalgae. ACS Symp Ser. 566: 255-270.
13. Banerjee, A., R.S. harma, Y. Chisti and U.C. Banerjee, 2002. Botryococcus braunii: A renewable source of hydrocarbons and other chemicals. Crit. Rev. Biotechnol., 22: 245-279.

14. Gavrilescu, M. and Y. Chisti, 2005. Biotechnology-a sustainable alternative for chemical industry. Biotechnol. Adv., 23: 471-99.
15. Fedorov, A.S., S. Kosourov, M.L. Ghirardi and M. Seibert, 2005. Continuous H2 photoproduction by Chlamydomonas reinhardtii using a novel twostage, sulfate-limited chemostat system. Appl. Biochem. Biotechnol., 124: 403-12
16. US Energy Information Administration. US energy outlook, Table A11 liquid fuels: diesel. Report #DOE/EIA-0383(2009). Available at: http://www.eia.doe. gov/oiaf/aeo/pdf/0383(2009).pdf; 2009 (accessed September 2009).
17.US Government Accountability Office. Crude oil: uncertainty about future oil supply makes it important to develop a strategy for addressing a peak and decline in oil production. US Government Accountability Office; 2007.
18.US Environmental Protection Agency. Alternative fuels: biodiesel. Report #EPA420-F-06-044. Available at: http://www.epa.gov/oms/smartway/ growandgo/documents/420f06044.pdf; 2006 (accessed September 2009).
19. US Energy Information Administration. US energy outlook, Table A11. Liquid fuels: biodiesel. Report #DOE/EIA-0383(2009). Available at: http://www.eia. doe.gov/oiaf/aeo/pdf/0383(2009).pdf; 2009 (accessed September 2009).
20. Benemann JR, Dunahy TG, Roessler PG, Sheehan J, Weisman JC. A look back at the U.S. department of energy’s aquatic species program e biodiesel from algae. Report NREL/TP-580-24190. National Renewable Energy Laboratory, US Department of Energy; 1998.
21. Benemann JR, Augenstein DC, Weissman JC. Summarized in [5], Microalgae as a source of liquid fuels. Appendix: technical feasibility analysis. U.S. Department of Energy, Final Report, Unpublished; 1982, 126 pp.
22. Weissman JC, Goebel RP. Design and analysis of pond systems for the purpose of producing fuels. Report SERI/STR-231e2840. Golden, Colorado: Solar Energy Research Institute; 1987. Summarized in [5].
23. Benemann JR, Oswald WJ. Systems and economic analysis of microalgae ponds for conversion of CO2 to biomass. Final Report. Pittsburgh Energy Technology Center; 1996. Summarized in [5].