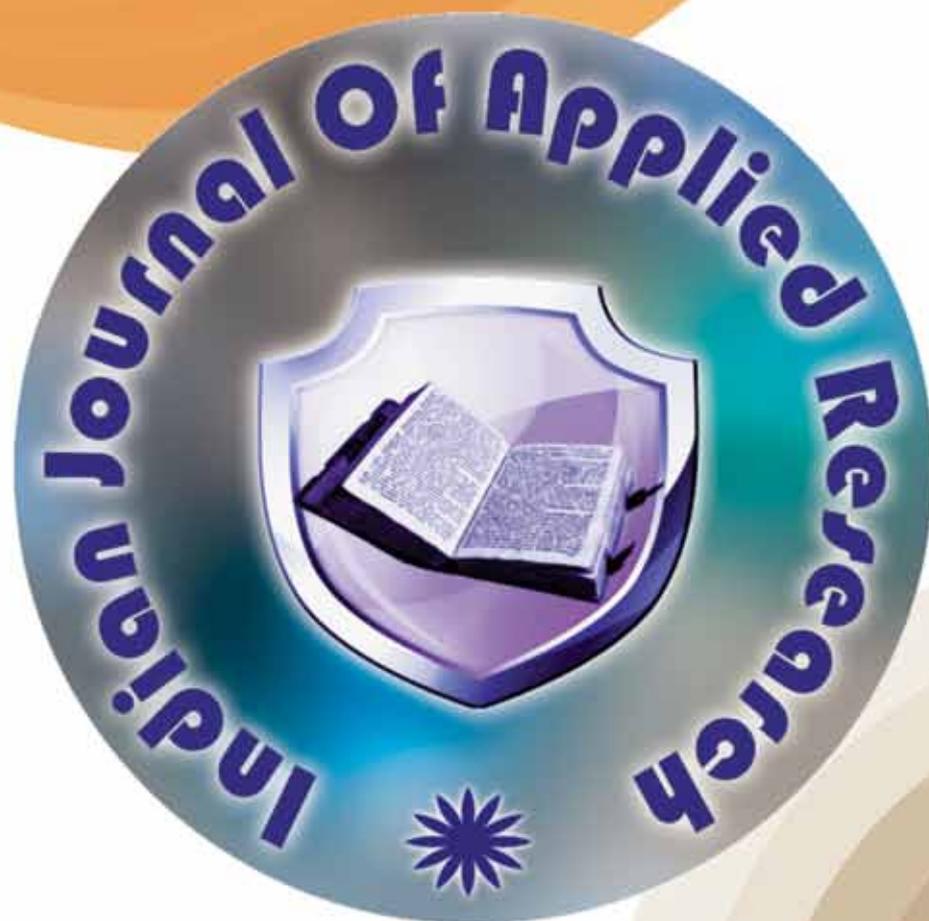


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Production Of Biodiesel From Microalgae Using Sodium Methoxide

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ABSTRACT

Biofuels are used to replace petroleum derived transport fuels, which is the main cause of global warming. Algae have emerged as one of the most promising source for biodiesel production. Like plants, microalgae use sunlight to produce oils but they do so more efficiently than crop plants. *Scenedesmus* sp., which found to be high in lipid content, was cultivated. The main objectives of the project is to make use of the algae present in the water bodies, extract microalgal oil, biodiesel conversion and GCMS study to meet the challenges of fuel requirement in the present scenario. Microalgal oil was extracted from *Scenedesmus bijugatus*. About 40 -50 % of oil were extracted from the freshwater microalgae. Biodiesel production from microalgae reached upto 85 percent with sodium methoxide catalyst. The GCMS study of biodiesel reported that the oil contained Palmitoleic (21.87%), Stearic (10.96%), Elaidic (19.19%).

Keywords : *Scenedesmus bijugatus*, Algal oil, Sodium methoxide, Transesterification, Biodiesel, GCMS study.

1. Introduction

The need of energy is increasing continuously, because of increase in industrialization and population. The basic sources of this energy are petroleum, natural gas, coal, hydro and nuclear (Kulkarni et al). The major disadvantage of using petroleum based fuels is atmospheric pollution created by the use of petroleum diesel. Petroleum diesel combustion is a major source of greenhouse gas (GHG). Apart from these emissions, petroleum diesel is also major source of other air contaminants including NO_x, SO_x, CO, particulate matter and volatile organic compounds (Klass et al).

Biomass is one of the better sources of energy. Biodiesel is made up of mono-alkyl esters of fatty acids derived from vegetable oils, used frying oils and animal fats. Most of the commercial biodiesel production is performed through transesterification reaction of triglycerides in vegetable oils, algal oil and animal fats with monoalkyl alcohols in the presence of homogenous base or acid catalyst (Berrios et al). When biodiesel is produced from other vegetable sources; feedstock cost contributes more than 70% to the cost of biodiesel. Recently because of rapid increase of the price of vegetable feedstock for biodiesel fuels, it as been considered to employ other inexpensive oil as a feedstock for biodiesel fuels.

The process of converting vegetable & plant oils into biodiesel fuel is called transesterification. Transesterification produces methyl esters of fatty acids that are biodiesel, and glycerol. The reaction occurs stepwise: triglycerides are first converted to diglycerides, then to monoglycerides and finally to glycerol. Transesterification is catalyzed by acids, alkalis (Fukuda et al., 2001; Meher et al., 2006) and lipase enzymes (Sharma et al., 2001). Alkali-catalyzed transesterification is about 4000 times faster than the acid catalyzed reaction (Fukuda et al., 2001).

Algae are the ultimate in renewable energy. The use of microalgae can be a suitable alternative because algae are the most efficient biological producer of oil on the planet and a versatile biomass source and may soon be one of the Earth's most important renewable fuel crops (Campbell, C.J., 1997).

Higher photosynthetic efficiency, higher biomass production, a faster growth rate than higher plants, highest CO fixation and O₂ production, growing in liquid medium which can be handled easily make the algae to stand high in front of other oil seed crops. Their production is not seasonal and can be harvested throughout the year (Chisti, Y., 2007 & 2008). As a matter of fact, average oil yield from microalgae can be 10 to 20 times higher than the yield obtained from oleaginous seeds and/or vegetable oils (Chisti, Y., 2008 & Tickell, J., 2000). Different types of biofuels can be derived from microalgae. These include methane produced by anaerobic digestion of algal biomass (Spolaore et al., 2006) biodiesel derived from microalgal oil (Roessler et al., 1994 & Banerjee et al., 2002) and photo-biologically produced bio-hydrogen (avrilescu, et al., 2005 & Fedorov, 2005) etc. Shay (1993) posited that algae were one of the best sources of biodiesel. It can produce up to 250 times the amount of oil per acre as soybeans. To the author's best knowledge, studies on microalgae *Scenedesmus bijugatus* as the feedstock for methyl ester production were never conducted. In the search for alternative oils for biodiesel production, algal oil presents a promising choice; in the present study, *Scenedesmus* algal oil was employed as a feedstock for biodiesel production in transesterification with methanol. Fatty acid methyl ester (FAME) content in the biodiesel product was evaluated. The composition of methyl esters and chemical properties of FAME were also investigated in the product.

2. Materials and methods

2.1. Culture conditions

Scenedesmus bijugatus used in this experiment was gifted by Centre for Advanced studies, Madras University, Chennai, Tamil nadu. The algae were grown in 1 L volumes in 2 L Erlenmeyer flasks. The inoculum for the strain was 5ml, containing about 5×10^4 cells /ml. the strains were cultivated at 24°C with a light: dark photoperiod of 14:10 h, with a light intensity of 115 $\mu\text{molm}^{-2}\text{s}^{-1}$ and were continuously stirred for aeration.

2.2 Experimental Site

Experiment was carried at Department of Biotechnology,

2.3. Biodiesel Production

Biodiesel was produced from algal oil with methanol over the alkali catalyst was carried out in a batch reactor equipped with a mechanical stirrer. In case of alkali transesterification-Methylation reagent: anhydrous methanol-hexane-sodium methoxide in the ratio 3:2:0.1 was taken. 5 ml of Methylation reagent was added to the algal lipid and heated for one hour at 50 – 60 0C. Finally methyl ester was extracted using pet ether, evaporated at 600C and weighed. Varying volume ratios of methanol, catalyst quantity, temperature and time, various reactions were conducted using the same alkali transesterification process. Various authors (Batel et al, 1980; Foidl et al, 1996; Darnoko, 1999; Darnoko and Cheryman, 2000 and Mohammed, 2006) have reported the use of transesterification procedures to produce methyl and ethyl esters (biodiesel) from various oils. From their works, one conclusion could be drawn: every oil has its own properties and characteristics and therefore a unique set of transesterification process parameters.

The oil percentage was calculated on the basis of the following formula:

$$\text{Percent oil in Alga} = \frac{\text{Weight of oil}}{\text{Weight of Algae}} \times 100$$

2.4. Analysis

The fatty acid methyl ester composition of oil was measured by GC analysis according to the EN 14103 test using agilent 6890 gas chromatograph unit equipped with FID at SGS Pvt Ltd, Chennai. The fatty acids were identified by chromatographic retention time by comparison with standards.

3. Results and Discussion

3.1 Effect of temperature

The basic reaction conditions were fixed as 60oC of reaction temperature, 1% weight of catalyst to algal oil, 1h of reaction time 5:1 molar ratio of Methylation reagent to feedstock. The biodiesel production to the reaction conditions was 85% on alkali catalyst. The high content of biodiesel was obtained at 55 – 60oC of reaction temperature as shown in fig.1. The reactivities of transesterification were higher in the reaction temperatures.

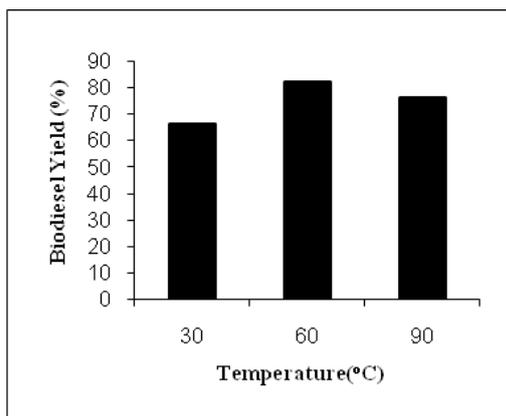


Fig: 1 Biodiesel production with variation of reaction temperature.

3.2 Effect of catalyst

The variation of the biodiesel production with different loading amounts of alkali catalyst is shown in Fig.2. The high content of biodiesel was exhibited at 2wt% of alkali catalyst loading to the feedstock. While the loading amount of catalyst exceeded more or less than 2wt%, the biodiesel production decreased reversely. It is clear therefore that increment in concentration

level of the catalyst would not yield further volume increase in biodiesel obtainable from microalgal oil. This could be explained from the viewpoint of the reversible nature of the transesterification process as opined by Darnoko (1999).

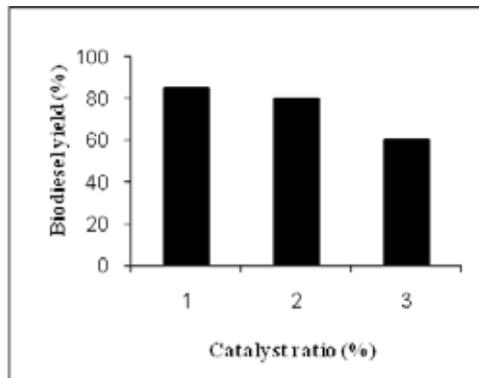


Fig: 2 Biodiesel production with variation of catalyst (sodium methoxide).

3.3 Effect of Methanol to Oil ratio

The effect of methanol addition was evaluated with the biodiesel production on alkali catalyst is shown in fig.3. When the methanol amount in the Methylation reagent was increased above the ratio level, the biodiesel production was 85%. However, the biodiesel content decreased with the increase in the methanol injection.

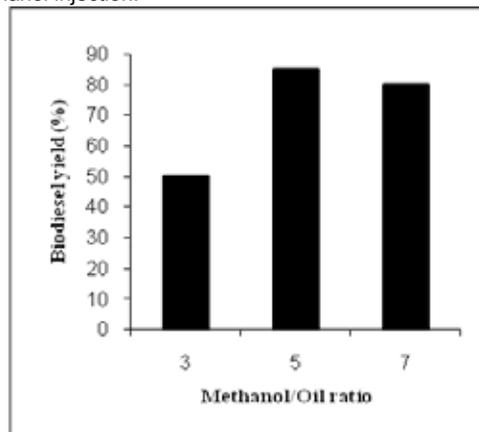


Fig: 3 Biodiesel production with variation of methanol.

3.4 Effect of Time

The biodiesel production with the reaction time is represented in Fig.4. The biodiesel production reached to 86% within 60 minutes and the production decreased with increasing time. This indicates that the process is time consuming will reduce the overall production cost.

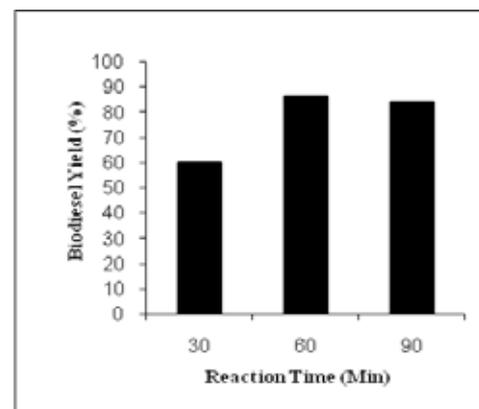


Fig: 4 Biodiesel production with variation of time.

3.5 GC-MS Analysis of Biodiesel

The biodiesel produced by transesterification on alkali catalyst was composed of palmitic acid (22%), oleic acid (19%), Arachidic acid (14.09%) and stearic acid (11%) as the major components. Table 1 lists the fatty acid composition of biodiesel produced by transesterification of algal oil with methanol at 60°C. It can be suggested that the microalgal source is more suitable as a feedstock for biodiesel fuel than vegetable oils, since it has a competitive price compared to the vegetable oils. The extracted microalgal oil consists of major fatty acids which is similar to vegetable oil in fatty acid composition

Table 1. Lists the fatty acid composition of biodiesel
Table3mpkinseedoilmethylester

Number of carbons	Fatty acid	Chemical structure	Weight (g/100g)
12	Lauric	CH ₃ (CH ₂) ₁₀ COOH	4.39
14	Myristic	CH ₃ (CH ₂) ₁₂ COOH	4.30
15	Pentadecanoic acid	C ₁₅ H ₃₀ O ₂	5.43

16	Palmitoleic	CH ₃ (CH ₂) ₅ CH=CH(CH ₂) ₇ COOH	21.87
16	Palmitic	CH ₃ (CH ₂) ₁₄ COOH	4.74
17	Heptadecanoic	CH ₃ (CH ₂) ₁₅ COOH	2.21
17	Heptadecenoic	CH ₃ (CH ₂) ₆ CH=CH(CH ₂) ₇ COOH	4.55
18	Stearic	CH ₃ (CH ₂) ₁₆ COOH	10.96
18	Oleic	CH ₃ (CH ₂) ₇ CH=CH(CH ₂) ₇ COOH	3.94
18	Elaidic	CH ₃ (CH ₂) ₇ CH=CH(CH ₂) ₇ COOH	19.19
20	Arachidic	C ₂₀ H ₄₀ O ₂	14.09

4. Conclusion

The production of biodiesel from microalgae *Scenedesmus* was evaluated by transesterification with methanol on alkali catalysts. The biodiesel production in the product was obtained upto 85% in case of sodium methoxide catalyst at 60°C within 60 minutes. The major constituent of the biodiesel product was palmitic acid (22%), oleic acid (19%), Arachidic acid (14.09%) and stearic acid (11%). The content of methyl esters in the biodiesel product came upto the limit of European biodiesel qualities for B100. Further investigation of biodiesel originated from microalgal oil can be widened by the examination of oil properties and the impact of algal oil methyl ester on the exhaust emissions in respect to other biodiesel.

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