SCOPE OF ALGAE AS A THIRD GENERATION BIODIESEL PRODUCTION

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Abstract: Biodiesel has gained much attension in recent year due to its eco-friendly nature and Non toxic characteristics. Continuous use of petroleum sourced fuels is now widely recognized as unsustainable because of depleting supplies and the contribution of these fuels to the accumulation of Carbon dioxide in the environment. Biodiesel derived from oil crops is a potential renewable and carbon neutral alternative to petroleum fuels. Unfortunately, Biodiesel from oil crops, waste cooking oil animal fat cannot realistically satisfy even a small fraction of the existing demand for transport fuels. Algae have emerged as one of the most promising sources for Biodiesel production. It can be inferred that Algae grown in CO_2 enrichedair can be converted to oily substances. Such an approach can contribute to solve major problems of air pollution resulting from CO_2 evolutionand future crisis due to a shortage of energy sources. In the current study, Algal species of Marine Algae were collected from Udwada beach, Valsad, Gujarat. In the first step oil from Algae species was extracted using n-hexane and Di-ethyl ether and the mixture of both as solvents, while in the second stage extracted oil was converted into biodiesel via transesterification reaction. Biodiesel production was highest in n-hexane solvent in Marine Algae. This study was undertaken to know the proper transesterification, amount of biodiesel production and physical properties of biodiesel.

***Indexterms-* Biodiesel, renewable energy, Algal oil, biomass, transesterification, glycerol**

I. INTRODUCTION

Carbon dioxide emission from transport sector is contributing major portion to the environmental pollution and global warming (Balat *et al*., 2010). The cost of crude oil will continue to rise due to diminishing supply, so production of fuel from alternate sources will be needed in the future decades (Du *et al*., 2008). In this scenario, biodiesel is the best alternate fuel due to its non-toxic nature (Lapinskiene *et al*., 2010). Sources of commercial Biodiesel include oil from waste cooking, corn, palm, animal fat, canola and jatropha. However, using plant oil for biodiesel production is not only controversial but also requires substantial quantity of land (Lee *et al*., 2011). Therefore, Algae is an alternate appropriate raw material for Biodiesel production (Chisti *et al*., 2010; Rawar *et al*., 2013).

Increasing population and industrialization has created serious problems of energy requirement. The current scenario of consumption of fuel has led to a situation that will be no oil reserves beyond 2050. Though, oil remains may be in a surplus amount, environmental pollution inclusive of CO_2, emission could be a jeopardizing effect globally, which might lead to climatic change (Yen *et al.*, 2013). The petroleum reserves are highly concentrated in certain regions of the world, therefore those countries not having these resources are facing energy/foreign exchange crisis, mainly due to import of crude petroleum. It is predicted that 45% of the total energy requirements would be fulfilled by oil and gas which has a vital role in satisfying energy needs of the world (Khan *et al.*, 2009). The petroleum reserves are highly concentrated in certain regions of the world, therefore those countries not having these resources are facing energy/foreign exchange crisis, mainly due to import of crude petroleum (Bisen *et al*., 2010).

The term Biodiesel was first coined by Wang in 1988. Biodiesel is the mono-alkyl esters of long chain fatty acids, which is derived from transesterification of biological matter. It is an excellent renewable and safe alternative fuel with environment friendly nature (Patil *et al*., 2011). Biodiesel production from renewable sourcescan also boost farming and fuel production industries (Xue *et al.*, 2006). The algae are now becoming the main source of biofuel production in the world. They are considered as the safer, non- competitive & rapidly growing organisms among those could be used for biodiesel production. They have the abilities to grow without much care on waste nutrients (Robert, 2013), and are considered the better source of biodiesel production as other sources can cause food problems as they are mainly including those plants which are used for food (Patil *et al*., 2008). Sources of commercial biodiesel include oil from waste cooking, corn, palm, animal fat, canola and jatropha. However, using plant oilfor biodiesel production is not only controversial but also requires substantial quantity of land (Lee *et al*., 2011). Studies showed that tobacco seeds can also be used for biodiesel production (Veljkovic *et al*., 2006).

The main advantages of Biodiesel, other than being a renewable energy source, is that its burning is much clearer than that of fossil fuel, and it can be used in the present diesel engines without modifications, Algae are one of the most exciting future solutions for our energy crisis, especially that of transportation fuel (Schenk, 2008). Algae need very low requirements to grow including carbon dioxide, sun light and water (Schenk, 2008).

Algae grow very fast and have lipid content higher. They have short generation time, i.e., they can double their mass every few hours (Schenk, 2008). Biodiesel can be produced through direct transesterification of algal biomass or by a two-step process which lipids are extracted, collected, and transesterified (Johnson and Wen, 2009). Either process requires lipid extraction using combinations of solvents and alcohols, such as chloroform/methanol, hexane/isopropanol, or petroleum ethers and methanol (Johnson and Wen, 2009;

Mulbry *et al.*, 2009). The direct method is advantageous, because it combines lipid extraction and transesterification into one process, making it less time-consuming than extraction transesterification processes (Johnson and Wen, 2009).

In the current study, potential Algal strains of *Ulva sp.* was used for the Biodiesel production. These strain was collected from Udwada beach, Valsad, Gujarat. In the first step oil from Algae species was extracted using n-hexane and Di-ethyl ether as solvents, while in second stage extracted oil was converted to biodiesel via transesterification reaction.

Algae can provide several different types of renewable biofuels. This include methane produced by anaerobic digestion of Algal biomass. The idea of using Algae as a source of fuel is not new but being taken seriously because of the escalating price of petroleum and, more significantly, the emerging concern about global warming that is associated with burning fossil fuels.

II. MEDIA

Reagent for oil extraction
- -n-hexane
- -Di-ethyl ether

Reagent for transesterification
- -NaOH
- -Methanol

III. RESEARCH METHODOLOGY

Collection of sample

Algae was collected from Udwada beach, Valsad, Gujarat. Algal growth was obtained for further investigation. Collection of Algae was done by hands in clean plastic containers in large quantity.

Identification of Algae

Samples of Algae which were collected from Marine source, underwent microscopic examination for the identification by using wet mount preparation techniques. Algae were identified according to their morphological characters by using as reference Bold and Wynne (1978) classification.

Drying of Algae

To make this process eco-friendly & economically cheap, collected Algal sample were divided to form small chunks & partially dewatered manually by pressing. Further samples were kept in the sun on the roof top for 3-5 days for complete drying at 25-28 ^{0}C.

Grinding of Algae

Dried Algal biomass was grind to powder by using motar and pastle. Further grinded Algal powder was pass through a sieve of 4mm diameter, from which the oversized particles were removed to obtain fine powder. Oversized particles were again grind to powder & sieved to obtained desired fine powder.

Extraction of oil from Algae

Solvents are used for extraction of oil from the obtained Algal powder. Oil from Algae was extracted by using n-hexane and Di-ethyl ether solvents. 50g Algal powder was mixed with 100 ml solvents.Solvents used were n-hexane, Di-ethyl ether and their mixture. Then above mixture were kept at room temperature for 24 hours.

Oil separation from Biomass

A layer of oil was formed on the surface of solvent, which was separated from the biomass using a funnel separator.

Evaporation

The extracted oil was separated from solvent by evaporation process in hot air oven at 60 ^{0}C for 10-15 minutes.

Mixing of catalyst & methanol

5ml of 1N NaOH (catalyst) was mixed with 50ml of methanol. The mixture obtained was vortex for 5-10 minutes for proper mixing.

Biodiesel production

The mixture of catalyst & methanol was poured into the Algal oil in a conical flask. The above mixture was kept in waterbath at 60^{0}C for 10-15 minutes. In this incubation the Transesterification reaction was carried out which formed two different layers. Top layer was of biodiesel where as bottom layer was formed of Glycerol. The reaction process is known as transesterification.

Triglyceride (oil)		Methanol (Alcohol)		Glycerol		Methyl esters (Biodiesel)
CH_2-OCOCR1				CH_2-OH		R1-$COOCH_3$
CH-OCOR2	+	3 $HOCH_3$	$\xrightleftharpoons{\text{Catalyst}}$	CH-OH	+	R2-$COOCH_3$
CH_2-OCOR3				CH_2-OH		R3-$COOCH_3$

Separation of biodiesel

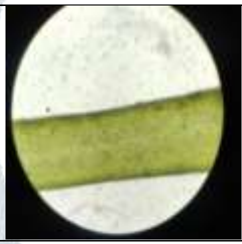
Flask separator was filled with mixture and was allow to kept for around 16 hours to settle the impurities and separate the Biodiesel and Glycerol layer. The top clear layer obtained was Biodiesel where as bottom layer obtained was Glycerol and impurities which was separated with help of flask separator.

IV. RESULTS AND DISCUSSION

Identification of Algal species

Microscopic identification of the obtained samples was indicated that the presence of Algae species, which morphologically similar to *Ulva sp.*

Table 1: Morphological characteristics of Algae by Microscopic Examination

Sample	Morphological characteristics	Name of Algae	Figure
Marine Algae	Bright, grass green, seaweed, consisting of inflated irregularly constricted tubular fronds.	*Ulva sp.*	

Drying and Grinding of Algae

Algae collected from marine source, were subjected to sundry for complete removal of water for around 3-5 days. The samples wereplaced on plastic sheet and direct sun exposure was provided during day time while in evening samples were kept in shade. The dried sampleswere grinded with motar and pastle, and samples were passed through sieve of 4 mm diameter.

(A) (B) (C)

Figure 1: Drying of Algae (A) Marine Algae (B) Grinding of Algae and (C) Pass through sieve

Oil Extraction from Algal species

Oil extracted from Algae by using Solvents n-hexane and Di-ethyl ether. Algae powder was mixed with solvent and their mixture and kept at room temperature for 24 hours. After 24 hours layerof oil was formed on solvent surface which was separated through flask separator. Oil extracted from Marine Algae by using different solvent and their combination gave different amount of oil which were given bellow.

Table 2: Oil Extracted using different solvent combination

Sr. no.	Algal sample		Solvent used			Extracted oil
	Quantity	Place	n-hexane	Di-ethyl ether	Mixture	
1.	50 g	Marine	100 ml	-	-	76 ml
2.	50g	Marine	-	100 ml	-	63 ml
3.	50g	Marine	50 ml	50 ml	-	67 ml

Biodiesel production through transesterification

The mixture of NaOH (catalyst) and Methanol were poured into Algal oil so transesterification reactions occur. The above mixture was kept in waterbath at 60^0C for 10-15 minutes which formed two different layers of Biodiesel and Glycerol, which was separated through flask separator. Top layer formed of Biodiesel and bottom layer was of Glycerol. Different layers of Biodiesel and Glycerol shown bellow.

Table 3: Observing different layers of biodiesel and Glycerol.

Sr. No.	Place	Solvent used	Observation of layers
1.	Marine	n-hexane	
2.	Marine	di-ethyl ether	
3.	Marine	n-hexane + di-ethyl ether	

Table 4: Biodiesel production from algae using different solvent

Sr. No.	Place	n-hexane	Di-ethyl ether	Biodiesel production (ml)
1.	Marine water	100 ml	-	50 ml
2.	Marine water	-	100 ml	-
3.	Marine water	50 ml	50 ml	-

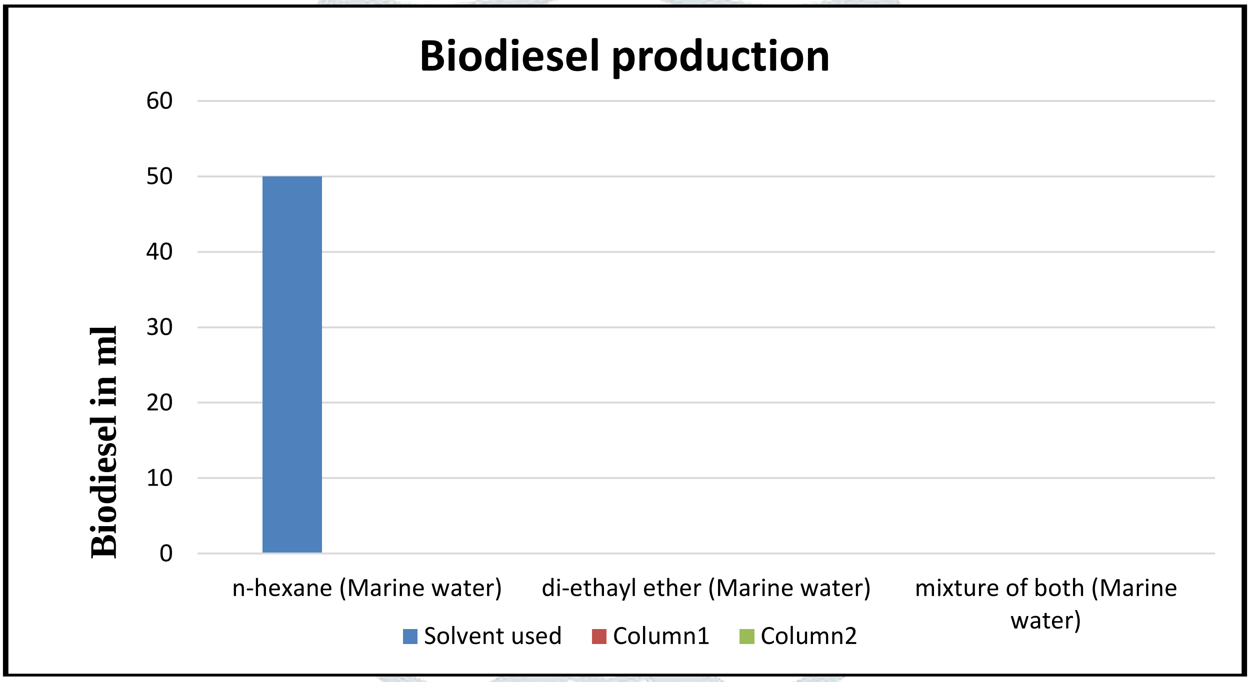


Figure 2 : Biodiesel production from different solvent mixture with Algae

Table 5: Comparative study of physical properties of biodiesel

Sr. No.	Properties	Standard Biodiesel	Petro-Diesel	Biodieselfrom Marine Algae using n-hexane solvent
1.	Colour of Biodiesel	Yellow	White (transparent)	Yellow
2.	pH of Biodiesel	7	7	7
3.	Flame test	Orange flame	Orange flame	Yellow flame
4.	Stabilitytest	160 seconds	147 seconds	90 seconds
5.	Density (kg/m^3)	797	802	707
6.	Kinematic viscosity (kg/m^3)	2.38	2.35	1.11
7.	Specific gravity	-	-	0.88
8.	Cloud point (^0C)	-4^0C	-4^0C	-4^0C

IV. CONCLUSION

Marine Algae was successfully used as a raw material for production of biodiesel. It is the only renewable biodiesel that can potentially completely displace liquid fuels derived from petroleum. Economics of producing Algal biodiesel need to improve substantially to make it competitive with petro-diesel, but the level of improvement is necessary appears to be attainable. The process involved two steps e.g., oil extraction and transesterification. It was noted that the maximum amount of biodiesel was obtained from the algalbiomass using n-hexane.

Algae are an economical choice for biodiesel production, Because of its availability and low cost. Our results prove that biodiesel can be produced from Marine Algae. In this way algae can be used as renewable energy.

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