BIODIESEL FROM BIOMASS AS AN ALTERNATE FUEL FOR AUTOMOBILE ENGINES

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ABSTRACT

Escalation of oil prices has perplexed mankind. Fossil fuels reserves are non-renewable and are getting depleted at a faster rate. Agriculture and industry use diesel powered engines for many purposes, but the supply of diesel fuel is limited. Diesel engines are widely used as power sources for medium and heavy duty applications because of their low fuel consumption. As worldwide fossil fuel reserves diminish due to consumption exceeding supplies, many countries are becoming increasingly dependent upon imported sources of oil. Bio-diesel is a renewable resource that could be sustainably supplied. India, being a peninsula is a rich source of seaweeds. Algal biodiesel, fuel from seaweeds is a third generation biodiesel which proves to be a better option compared to its competitors of edible and non-edible vegetable oils in terms of yield, land area required and the turn – over frequency. This paper evaluates the possibility of producing biodiesel from a macroalgae Chaetomorpha Aerea and the evaluation of the biodiesel according to ASTMD6751.

Keywords: Fossil fuels, Seaweeds, Chaetomorpha Aerea, biodiesel, ASTM

I. INTRODUCTION

The world is facing declining fuel reserves when energy demand is exploding. Biodiesel derived from green algae biomass has the potential for high volume, cost effective production. It can be carbon neutral and produced intensively on relatively small areas of marginal land. The quality of the fuel product is comparable to petroleum diesel and can be incorporated with minimal change into the existing fuel infrastructure. [1] There are basically three generation of biofuels. The biodiesel produced from edible vegetable oils like palm oil, soybean, canola oil etc., are the first generation biofuels. The second generation biofuels are the biodiesel produced from non-edible vegetable oil like jatropha. The third generation biofuel is the biofuel from algae both microalgae and macroalgae. Macroalgae or seaweeds is available in abundance in India and it is a raw material which requires much exploration and utilization. Currently they are used in food, water treatment, fertilizer, pigment, pharmaceutical industries etc.,

Algae are now being looked upon as a viable source for biofuel production.

II. EXPERIMENTAL MEHODOLOGY

The green macroalgae Chaetomorpha Aerea was obtained from kovalam beach, Chennai. This was washed in sea water to remove the sand and other impurities. The cleaned algae were dried in a tray drier at about 55°C to remove the water content. One kilogram of wet algae was collected. After drying 880 gm of dry weight of algae was obtained. The dried algae were ground with a mortar and pestle as much as possible and the oil was extracted by the solvent extraction method using hexane and ether as the solvent. 20 ml of hexane and 20 ml of ether were added to the ground algae and the mixture was kept for 24 hr settling. The oil is filtered and the bio mass collected from both the species is weighed. The transesterification process is the reaction of triglyceride with an alcohol to form esters and glycerol. A mixture of methanol and the base catalyst sodium hydroxide (50 ml of methanol and 0.25 g NaoH) is added to the extracted algal oils in a conical flask and this mixture was kept in a magnetic shaker at about 1500 rpm for 3 hours. The following reaction takes place

$$\mathbf{RCOOR' + R'' \longrightarrow RCOOR'' + R'\,OH - (1)}$$

After shaking the solution was kept for 15 hr to settle the bio-diesel and sediment layers clearly in a separating flask. The two layers formed were carefully separated and the bio-diesel was kept separately and the sediment (glycerine, pigments, etc) was measured. The Bio-diesel was washed by 5% water until it was become clean. Bio-Diesel was dried by using dryer and finally kept under running fan for 12 hr.The Bio-diesel obtained was measured using a measuring cylinder and was stored in a dried container for further analysis.

III. RESULTS & DISCUSSION

One kilogram of wet algae was collected. After drying 880 gm of dry weight of algae was obtained.

Yield Percentage = Weight of Product/Weight of raw oil

Yield Percentage of Chaetomorpha Aerea

$$= 210/265.61 \times 100 = 79.06$$

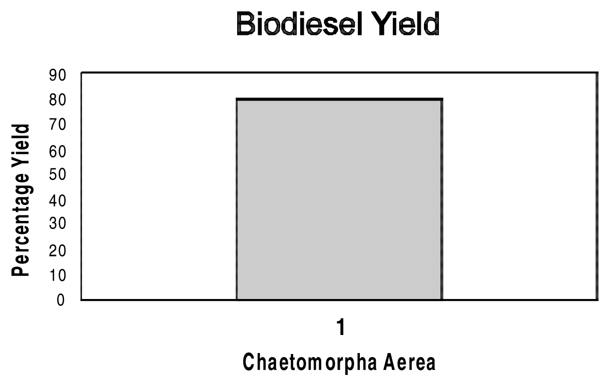

Fig. 1. Biodiesel Yield

The stored sample was given for analysis according to the standards prescribed by American Society of Testing Materials (ASTMD6751).

Table 1. Performance Standards

Parameter	Algal biodiesel	ASTM D6751	Units
Kinematic viscosity	4.29	2.5 - 6.0	CSt
Sulphur content	0.005	.015	% mass (max)
Water content	0.043	0.05	% vol (max)
TotalGlycerol	0.3	0.24	% mass (max)
Iodine value	69.3	<115	g/100 g
Acid Number	0.38	0.50	mgKOH/gm
Flash point	160	min 100	°C
Visual Appearance	Golden brown	Brownish Yellow	———
Calorific Value	9872	10170	cal/g
Cetane Number	54	47 min	
Conradson carbon residue	0.18	0.1	(% w/w)

A. Kinematic Viscosity:

Kinematic viscosity plays an important role in determining fuel characteristics. In addition of lubrication of fuel injection system components, fuel viscosity controls the characteristics of the injection from the diesel injector like droplet size, spray characteristics etc., The viscosity of methyl esters can go to very high levels and hence, it is important to control it within an acceptable level to avoid negative impact on fuel injection system performance. The value of kinematic viscosity is well within the permissible limits.

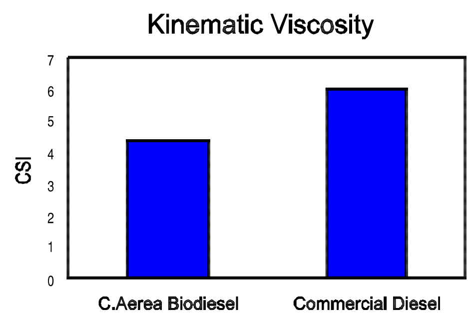

Fig. 2. Kinematic Viscosity

B. Density:

Bio-diesel is slightly heavier than conventional diesel fuel This allows use of splash blending by adding bio-diesel on top of diesel fuel for making bio-diesel blends. Bio-diesel should always be blended at top of diesel fuel. If bio-diesel is first put at the bottom and then diesel fuel is added, it will not mix. The density of Chaetomorpha Aerea Biodiesel is higher than conventional diesel.

C. Flash point:

Flash point of a fuel is defined as the temperature at which it will ignite when exposed to a flame or spark. The flashpoint of bio-diesel is higher than the petroleum based diesel fuel. Flashpoint of bio-diesel blends is dependent on the flashpoint of the base diesel fuel used, and increase with percentage of bio-diesel in the blend. Thus in storage, biodiesel and its blends are safer than conventional diesel. The flashpoint of bio-diesel is around 160°C, but it can reduce drastically if the alcohol used in manufacture of bio-diesel is not removed properly. Residual alcohol in the bio-diesel reduces its flashpoint drastically and is harmful to fuel pump, seals, elastomers etc. It also reduces the combustion quality.

Peak #	Ret Time [min]	Type	Width [min]	Area [pA*s]	Area	Name
1.	4.861		0.0000	0.00000	0.00000	Butyric ME C4
2.	7.226		0.0000	0.00000	0.00000	Caproic ME C6
3.	9.031		0.0000	0.00000	0.00000	Caprylic ME C8
4.	10.482		0.0000	0.00000	0.00000	Capric ME C10
5.	11.124		0.0000	0.00000	0.00000	Undecanoic ME C11
6.	11.734	BB	0.0296	3.71682	0.25220	Lauric ME C12
7.	12.287		0.0000	0.00000	0.00000	Tridecanoic ME C13
8.	12.762	BB	0.0222	38.29747	259859	Myristic ME 14
9.	13.124		0.0000	0.00000	0.00000	Myristoleic ME C14;1
10.	13.325		0.0000	0.00000	0.00000	Pentadecanoic ME C15
11.	13.630		0.0000	0.00000	0.00000	Pentadecanoic ME C15:1C
12.	13.782	BB	0.0254	1025.46973	69.58085	Palmitic ME C16
13.	14.129		0.0000	0.00000	0.00000	Palmitoleic ME C16:1
14.	14.327	VP	0.0243	22.76040	1.54435	Heptadecanoic ME C17
15.	14.610		0.0000	0.00000	0.00000	Heptadecanoic ME C17:1C
16.	14.782	MM	0.0487	73.35067	4.97704	Stearic acid ME C18
17.	15.049	MF	0.0311	48.72641	3.30622	Eladic acid ME C18:1t
18.	15.096	FM	0.0284	35.02279	2.37639	Oleic acid ME C18:1C
19.	15.306		0.0000	0.00000	0.00000	Lenoelidicacid Me C18:2t
20.	15.467	BP	0.0297	107.75860	7.31171	Linoleic ME C18:2c
21.	15.854		0.0000	0.00000	0.00000	Linolenic ME C18:3
22.	16.007	BB	0.0330	118.67853	8.05266	Arachidic ME C20:0
23.	16.078		0.0000	0.00000	0.00000	g-Linolenic ME C18:3c
24.	16.381		0.0000	0.00000	0.00000	11-Eicosenoic ME C20:1
25.	16.772		0.0000	0.00000	0.00000	Henieicosanoic ME C21:0
26.	16.956		0.0000	0.00000	0.00000	B, 11, 14-Eicosatrienoic ME C20:3c
27.	17.388		0.0000	0.00000	0.00000	11, 14-Eicosatrienoate ME C20:2
28.	17.623		0.0000	0.00000	0.00000	Arachidonic ME C20:4
29.	17.723		0.0000	0.00000	0.00000	Behenic acid ME C22.0
30.	18.097		0.0000	0.00000	0.00000	Euricic ME C22:1
31.	18.606		0.0000	0.00000	0.00000	5, 8, 11, 14, 17-Eicosapentanoic acid ME C20:5
32.	18.658		0.0000	0.00000	0.00000	Tricosanoic ME C23:0
33.	18.896		0.0000	0.00000	0.00000	11, 14, 17-Eicosatrienoate ME
34.	19.621		0.0000	0.00000	0.00000	Lignoceric ME C24:0
35.	20.086		0.0000	0.00000	0.00000	Nervonic acid ME C24:1
36.	20.956		0.0000	0.00000	0.00000	4, 7, 10, 13, 15, 19-decosahexanoic acid ME C22:6

Fig. 3. Chemical Composition of Biodiesel

D. Iodine Number:

In diesel engines, Methyl esters have been known to cause engine oil dilution by the fuel. A high content of unsaturated fatty acids in the ester (indicated by high Iodine number) increases the danger of polymerization in the engine oil. Oil dilution decreases oil viscosity. Sudden increase in oil viscosity, as encountered in several engine tests, is attributed to oxidation and polymerization of unsaturated fuel parts entering into oil through dilution. In saturated fatty acids all the carbon is bound to two hydrogen atoms by double bonds. More the double bonds the lower is the cloud point of oil. The tendency of the fuel to be unstable can be predicted by Iodine number. Different bio-diesel have different stability performance.

When iodine is introduced in the oil, the iodine attaches itself over a single bond to form a double bond. Thus iodine number refers to the amount of iodine required to convert unsaturated oil into saturated oil. It does not refer to the amount of iodine in the oil but to the presence of unsaturated fatty acids in the fuel. Iodine number of Chaetomorpha Aerea Biodiesel is well within the permissible limits.

E. Free and Total glycerol:

The degree of conversion of the vegetable oil is indicated by the amount of free and total glycerol present in the bio-diesel. If the actual number is higher than the specified values, engine fouling, filter-clogging etc can occur. Manufacturing process controls are necessary to ensure low free and total glycerin. Free glycerol if present can build up at the bottom of the storage and vehicle fuel tanks. Glycerol content of Chaetomorpha Aerea is higher than the permissible limits.

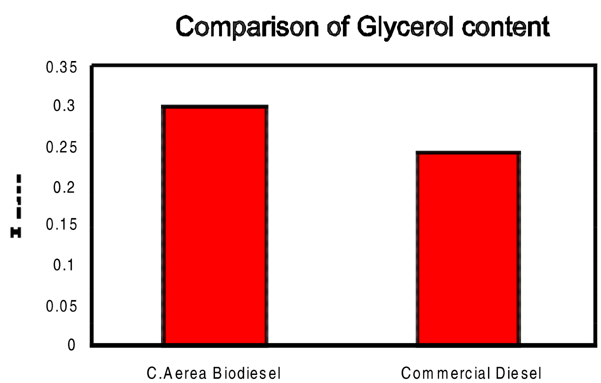

Fig. 4. Glycerol Yield

F. Sulfur content:

Biodiesel generally contain less than 15 ppp sulfur. Sulfur content is less than the prescribed limits of ASTMD6751.

G. Acid number/Neutralization number:

Acid number or Neutralization number is specified to ensure proper ageing properties of the fuel and a good manufacturing process. Acid number reflects the presence of free fatty acids or acids used in

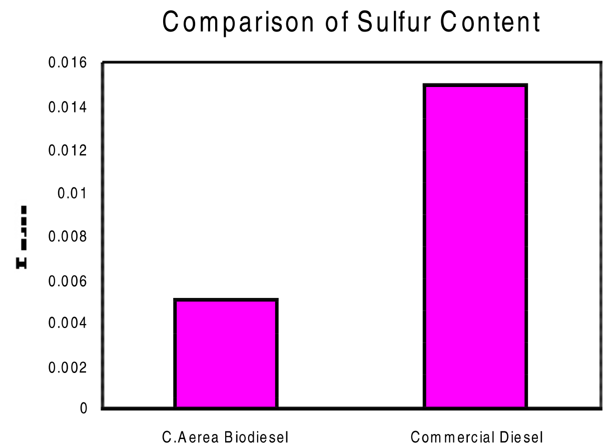

Fig. 5. Sulfur Content

manufacture of biodiesel. It also reflects the degradation of biodiesel due to thermal effects. For example, during the injection process several times more fuel returns from the injector than that injected into the combustion chamber of the engine. The temperature of this return fuel can, sometimes, be as high as 90°C and thus accelerate the degradation of biodiesel. The resultant high acid number can cause damage to injector and also result in deposits in fuel system and affect life of pumps and filters. Sodium hydro peroxide and sulfuric acids are highly corrosive and can cause serious, many times permanent, injuries. The acid number value is well within the permissible limits.

H. Water Content:

Biodiesel and its blends are susceptible to growing microbes when water is present in fuel. The solvency properties of the biodiesel can cause microbial slime to detach and clog fuel filters. Water content of Chaetomorpha Aerea biodiesel is within the permissible limits.

IV. CONCLUSION

Seaweed biofuels have the potential to replace a significant portion of the total diesel used today with a smaller environmental foot print. In addition ,algal biofuel production can be carried at using marginal land and saline water, placing no additional pressure on land needed for food production and freshwater supplies. Algal biofuels have the potential to mitigate the impact of green house gases from point sources. Chaetomorpha Aerea seaweed was investigated for production of bio-diesel. The bio-diesel obtained from Chaetomorpha Aerea met the standards prescribed by

ASTM except for glycerol content which can be overcome by blending with commercial diesel.

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