A STUDY OF EXTRACTION & BIODIESEL SYNTHESIS FROM SEWAGE SLUDGE

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ABSTRACT

The issue of energy crisis is being faced globally. Especially in the developing countries like India wherein the fuels are imported from other nations, it is an inevitable matter that non-renewable fuels are going to exhaust in near future. The bio-fuels are the most promising alternatives to look forward. Presently, India is focusing on blending and replacing 20% of conventional fuel with biofuel. The biodiesel is already being synthesized from non-edible oil seeds but the cultivation lands and its cost is again an issue. Moreover, the sewage treatment plants are in operation at massive scale which generates a lot of sludge. This study describes the competitivity of synthesizing Biodiesel from sewage sludge of a STP at Pirana, Ahmedabad, India. The yield of lipid extraction from various samples of sludge is discussed.

Keyword: - *Biodiesel, Lipid Extraction, Transesterification, Sewage Sludge, Pirana STP*

1. INTRODUCTION

The economy of India is growing tremendously. The object of focus for development enumerates to various aspects like equity, economic growth, infrastructural growth, human well-being and sustainable development of the natural resources of the country. Energy security and environmental issues are a decisive factor on which the facilitated growth of developing countries can be stimulated to create economic balance as well as employment opportunities. Another major turn down is the lack of non-renewable fuels. The prices of fuels are hiking up every year therefore; there is an inevitable need to bridge the gap between energy and supply. The Indian approach to biofuels merely focuses on nonfood feedstock to be raised on degraded or waste lands that are not suitable for agriculture, thus avoiding a possible conflict of fuel versus food security. At present, experiments are going on at various levels to produce biodiesel from jatropha seeds for lighting stoves, lamps, running pump sets for irrigation and locomotives.

Biodiesel is a most promising substitute which can be used as blends with diesel. It is the most competent green fuel which can replace the diesel in an appreciable amount as compared to other biofuels such as bioethanol, biohydrogen and biogas. Chemically, biodiesel can be defined as a fuel composed of mono-alkyl esters of long chain fatty acids derived from renewable sources like lipids & animal fat and used cooking oil designated as B100. Biodiesel has been generated from various feedstocks which contain organic compound like soya-beans, sunflower seeds, jatrofa seeds, etc. But since these feedstocks are not available in abundance, the price of raw materials required to manufacture biodiesel becomes equivalent to that of petroleum diesel. Keeping in mind this approach, municipal sludge plays a seamless feedstock as it's abundantly available from the sewage waste water, it is renewable, economic and above this, it also serves the tactics of waste management

The basic characteristics of biodiesel on comparison to high speed diesel are [1]:

Table 1: Comparison of HSD and Biodiesel

SR.	PARAMETER	HSD PETRO DIESEL	BIODIESEL
1	Cetane No	45	58 – 62
2	Carbon Residue % mass	0.35	<0.05
3	Flash Point 0°C	60	>145
4	Sulphur Content% mass	0.25	<0.0002
6	Calorific Value Kcal/kg	10700	9600
7	Density at 150°C kg/m³	883	874
8	Boiling Point 0 °C	215 - 376	>290
9	Melting Point 0 °C	N.A.	12

In this study, sewage sludge that is obtained as a solid waste from the sewage treatment plant has been taken as feedstock for generating biodiesel out of it. The study was carried out in two processes – Lipid Extraction and Transesterification. The sewage sludge obtained from sewage treatment plant contains large amount of organic content. This study is carried out with the sludge samples of Sewage Treatment Plant of capacity 106 KLD at Pirana Village, Ahmedabad, India; which falls under the management of Ahmedabad Municipal Corporation.

2. MATERIALS AND METHODS

2.1 Materials

The sludge samples from Primary Treatment & Secondary Treatment were taken as the base feedstock for the experiment. Hexane was used as solvent for extraction of lipids from the sludge samples. Methanol of HPLC Grade was used for transesterification process in presence of Potassium Hydroxide. Magnesium Sulphate Monohydrate ($MgSO_4$-H_2O) was used to dry the methyl ester [5]. The instruments used to carry out the study are: Desiccator, Soxhlet Extractor, Condenser, Muffle Furnace, Separating Funnel, Vacuum Filter and Gas Chromatography for final analysis.

2.2 Sample Preparation:

Three samples were taken: primary sludge, secondary sludge and combined sludge from both. The sludge samples were dewatered by drying them. Once the sludge samples were completely moisture free, all the three samples were powdered down to fine particles.

2.3 Lipid Extraction:

The samples were weighed and poured in a cellulose thimble of 19x19 mm dimension. The cellulose thimble was then packed with glass wool in order to prevent the control the interaction of powdered sludge with solvent. The Soxhlet Extractor was used for the extraction of lipids. As shown in the figure 1 given below, the Soxhlet Appartus is divided into three sections: Percolator in which distillation flask is placed, Soxhlet Extractor in which the thimble with sludge sample is placed, Condenser. The Soxhlet extraction works on Siphon Mechanism wherein, the solvent when heated, its vapours get condensed in the condenser and fall down to the Extractor. The solvent remains in contact with the powdered sludge and only after its concentration reaches that level of siphon, it gets recollected in the distillation flask. Such 90 cycles were carried out for each powdered sludge sample. The given method was performed as per the standard method 5520 E {14} for lipid extraction. The lipids from the sludge get trapped in the solvent used. Here, Hexane was used as a solvent. The lipids were then collected from the solvent by heating. On heating, the solvent evaporated and the lipids were left behind. This was done for laboratory scale only, on experimental basis, solvent recovery can be obtained for almost up to 98%. The solvent extraction of sludge samples was also done using methanol as the solvent [6].

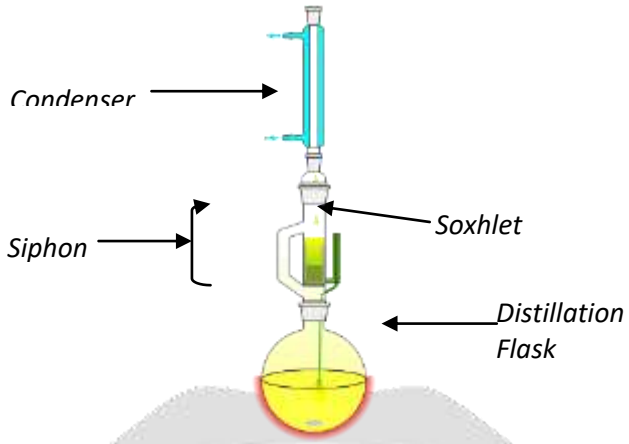

Figure 1: Soxhlet Apparatus

2.2 Transesterification

The lipids synthesized from the sludge sample by the means of Soxhlet apparatus were then made to react with HPLC Grade Methanol for preventing influence of any impurities. The base catalyzed reaction was done to convert the lipids into FAMEs i.e. Fatty Acid Methyl Esters. The end product from the reaction of triglyceride which were the lipids and alcohol are glycerol and esters. For this study, methanol was reacted with triglycerides to form glycerol and methyl ester. The obtained impurities might contain impurities were therefore filtrated by the membrane coated with base catalyst KOH in order to achieve uncontaminated methyl ester. The glycerol and methyl ester were then separated by separating funnel. The lower layer of glycerol was drained off and the above layer of methyl ester was collected in a flask. Hexane was added to the separating funnel in order to collect the methyl ester since it was too sticky and viscous to collect it effortlessly. Now to wash the hexane phase, vacuum filtration was done. The filtrate was then collected in a glass vial and sent for Glass Chromatography for analysis.

3. RESULTS

The biodiesel collected was then analyzed by Gas Chromatography using an Agilent gas chromatograph 6890GC with Flame Ionization Detector (FID), with Helium as carrier gas. with a constant injector temperature 260ºC. The injection volume of sample was 1.5 □L with a split ratio 20/1. The FID was at 260ºC for the duration of the analysis. The oven temperature programme was start from 150 ºC, holding for 1 min and then increased by 2.9 ºC/min to 230 ºC, holding for 1 min [5]. The parameters analysed and the results obtained are shown below:

Table 1*:* Results of Generated Biodiesel

PARAMETERS	UNIT	RESULTS	ASTM STANDARDS
Density @ 15 ˚C	Kg/m^3	894	--
Kinematic Viscosity mm^2/s	CP	13.53 (40 ˚C),	1.9 – 6.0
Flash Point	˚C	132	130 min
Sulphur Content	% by Mass	0.001	0.0015 (max) (S15)
Carbon Residue Content	% by Mass	0.016	0.050 (max)
Water Content	0	0.065	0.050 (max)
Total Contamination	% by Mass	0.13	-
Copper Strip Corrosion at 3 hours at 50 ˚C	--	Nil	No. 3 (max)
Cetane Number	--	61	47 min
Acid Number	Mg KOH/g	0.401	1.00 (max)

Methanol Content	% by Mass	0.14	--
Ethanol Content	% by Mass	0.18	--
Total glycerol Content	% by Mass	0.16	0.24
Iodine Value	-	113	--
Viscosity Index	--	101	>90
Gross Calorific Value (By Bomb Calorimeter)	MJ/Kg	35.44	50
Fire Point	˚C	125	150 (max)
Iron	ppm	8	25 (max)
Chromium	ppm	2.22	15 (max)
Aluminium	ppm	2.53	15 (max)
Manganese	ppm	0.77	5.0 (max)
Calcium	ppm	7.43	10.0 (max)
Phosphorous	ppm	19	50.0 (max)

4. CONCLUSIONS

The yield of lipids from primary sludge and secondary sludge was 17% and 14% respectively. The yield from the sample made by combining both the sludge samples was 21%. It was also observed that the yield of lipid extraction from primary sludge was more efficient with methanol as the solvent rather than hexane. The study revealed that the biodiesel generation from sewage sludge is as competent as that of the biodiesel synthesized from non-edible oil seeds like jatropha. Moreover, it is economic enough since the resource mainly used will be electricity and the other solvents, water and other reagents used can be recovered from the process itself. Therefore, it is a new epitome for energy generation from waste.

5. REFERENCES

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