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PRODUCTION OF BIODIESEL FROM WASTE COOKING OIL

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Abstract:With the increase in crude oil prices use to day by day life, the need for development of economically attractive alternate fuels has increased. Production of biodiesel from all waste cooking oil is one such raw materials or alternative. The project involves setting up of a laboratory scale production unit for biodiesel Conversion from waste cooking oil, collected from different sources. Methanol, with sodium hydroxide and other components as a catalyst, reacts with the waste oil in the Transesterification process in our laboratory producing fatty acid methyl ester (FAME) with glycerine as a by-product. Properties of our sample including density, viscosity, flash point, pour point, sulphur content, cetane index are tested according to ASTM standards and compared with those of petroleum diesel, establishing the sample as complete biodiesel. The project will also include blending of biodiesel with petroleum diesel and their properties to be tested and to be compared. The production of biodiesel from waste cooking oil offers economic and environmental solutions along with waste management. The project, thus aims at utilizing leftover cooking oil, for a possible conversion to biodiesel.

KEYWORDS: Biodiesel, waste cooking oil, Transesterification, FAME (fatty acid methyl esters).

I. Introduction

21st century has been facing many problems like energy sustainability, environmental problems and rising fuel prices. Conventional fuels are known for polluting air by emissions of sulfur dioxides, carbon dioxides, particulate matter and other gases.[1] This has resulted to increase research in alternate fuels and renewable source of energy. Recently biodiesel is a most suitable fuel for use in diesel engines that is comprised of fatty acid monoalkyl ester dried from vegetable oils, microalgal oil, and animal fats. Biodiesel is nontoxic and biodegradable. Bio-diesel is a green fuel, which does not contribute in carbon dioxide burden because such fuel is made from agriculture material.[2][3][4] for use in diesel engines that is comprised of fatty acid monoalkyl ester dried from vegetable oils, microalgal oil, and animal fats.[5][6][7][8][9] Biodiesel is nontoxic and biodegradable. Bio-diesel is a green fuel, which does not contribute in carbon dioxide burden because such fuel is made from agriculture material.[10] Bio-diesel has a high flash point and it is non-toxic, so classed as non-hazardous. Biodiesel can be used alone, or blended with Petro diesel in any proportions. [11] Currently, India produce only 30% of the total petroleum fuels required for its consumption and the remaining 70% is imported, which costs about 80000 million per year.[12][13] It is evident that mixing of 5% of biodiesel fuel to the present diesel fuel can save 40000 Million per year.[14]

2. Methods of production

2.1 Direct use of blending

This method does not require any chemical process. In this method vegetable oils diluted in diesel to reduce its viscosity. The direct use of vegetable oils in diesel engine is not favorable and problematic. It required some chemical modification before can be used into the engine.[15] Energy consumption in the case of these oils are found equivalent to diesel fuel. The ratios of oil to diesel 1:10 – 2:10 was found successful. But at the end, the use of direct oils or blend of oils was not satisfactory with regard to direct or indirect usage as diesel fuels.[16]

2.2 Micro Emulsion process

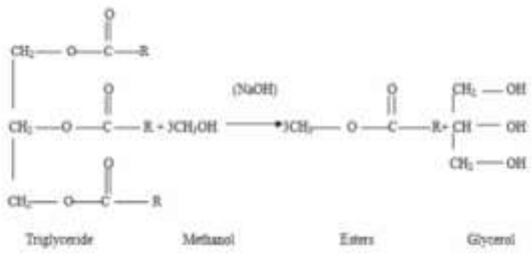
By using the solvent such as methanol and ethanol by micro emulsion process, problem of high viscosity was solved. Micro-emulsion results in reduction in viscosity increase in cetane number and good spray characters in the biodiesel. Use of micro- emulsified diesel in engines causes problems like injector needle sticking, carbon deposit formation and incomplete combustion.[16] The fuels of this kind are also termed as hybrid fuels. The problem of high vegetable oil viscosity can be overcome by micro-emulsification. A micro-emulsion is defined as a colloidal equilibrium dispersion of optically isotropic fluid microstructures with dimensions in the range of 1–150 nm, formed spontaneously from two normally immiscible liquids and one or more ionic or non-ionic amphiphiles. They exist as three components namely an oil phase, an aqueous phase and a surfactant. The maximum viscosity limitation required for diesel engines can be met by micro-emulsions with butanol, hexanol and octanol.[17]

2.3 Thermal Cracking (Pyrolysis)

Thermal cracking is the thermal decomposition of the organic matters in the absence of oxygen and with the catalyst used in process. Thermal cracking is also known as Pyrolysis. The equipment for thermal cracking and pyrolysis is expensive. Another disadvantage of pyrolysis is the need for separate distillation equipment for separation of the various fractions. Pyrolysis is the conversion of an organic compound into another organic compound by means of heat with the help of catalyst. Animal fats, vegetable oils, natural fatty acids or methyl esters of fatty acids can be used as pyrolyzed material. In the case of animal fats and vegetable oils conversion, triglycerides play an important role and thus the thermal cracking reactions. It is a promising technology for biodiesel production. The pyrolysis reactions can be divided into catalytic and non-catalytic reactions. The points to be considered are the expensive equipment for the process and all possibilities of more gasoline production than diesel fuel.[18]

2.4 Transesterification

The Transesterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol. A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerine.[19][20][21] The nature of the fatty acids can in turn affect the characteristics of the biodiesel. During the esterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide.[22][23][24] The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerol. In most production methanol or ethanol is the alcohol used (methanol produces methyl esters; ethanol produces ethyl esters) and is base catalysed by either potassium or sodium hydroxide. Potassium hydroxide has been found to be more suitable for the ethyl ester biodiesel production, either base can be used for the methyl ester.[25] A common product of the transesterification process is Rape Methyl Ester (RME) produced from raw rapeseed oil reacted with methanol. The reaction is below the chemical process for methyl ester biodiesel.[26] The reaction between the fat or oil and the alcohol is a reversible reaction and so the alcohol must be added in excess to drive the reaction towards the right and ensure complete conversion.[27] There are three basic routes to biodiesel production from oils and fats: (1) Catalyst base transesterification of oil, (2) Direct acid catalyst transesterification of the oil, (3) Conversion of the oil to its fatty acid then biodiesel, Almost all biodiesel is produced using base catalysed transesterification as it is the most economical process requiring only low temperatures and pressures and producing a 98% conversion yield. For this reason, only this process will be described in this report.[28][29]
Chemical reaction is given below:



The reaction between the fat or oil and the alcohol is a reversible reaction and so the alcohol must be added in excess to drive the reaction towards the right and ensure complete conversion.[30][31] A successful transesterification reaction is signified by the separation of the ester and glycerol layers after the reaction time.[32] The heavier, co-product, glycerol settles out and may be sold as it is or it may be purified for use in other industries, e.g. the pharmaceutical, cosmetics etc.[33]

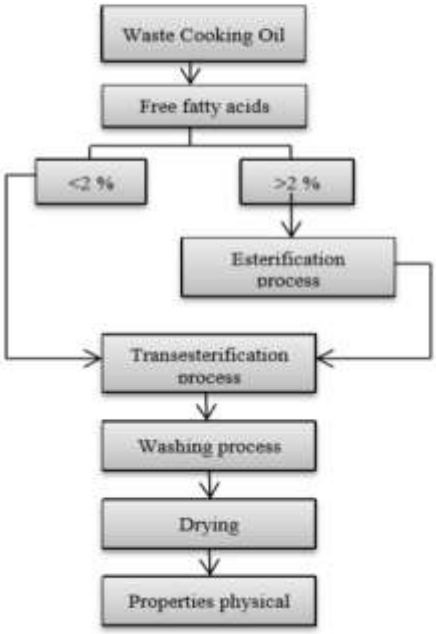


Fig.1: Flow diagram of production of biodiesel.

Feedstock of Waste cooking oil

The waste cooking oil is generated from the fried food, which need large amounts of oil because it requires the full immersion of food at temperatures greater than 180 °C. Accordingly to the high temperatures are generated changes in its chemical and physical composition, as well as in its organoleptic properties which affect both the food and oil quality.[34] Reuse of domestic oil has a high risk to the health of consumers as depending on the type of food subjected to frying, “this absorbs between 5% and 20% of the used oil,which can increase significantly the amount of hazardous compounds that provide degraded oil to food”. “In an alkali catalyzed process is reached high purity and high yields in short periods of time ranging between 30 - 60 minutes”.[35] Used cooking oil is normally black, a strong odor and does not have large amount of solids because its collection is passed through a fine mesh.[36]

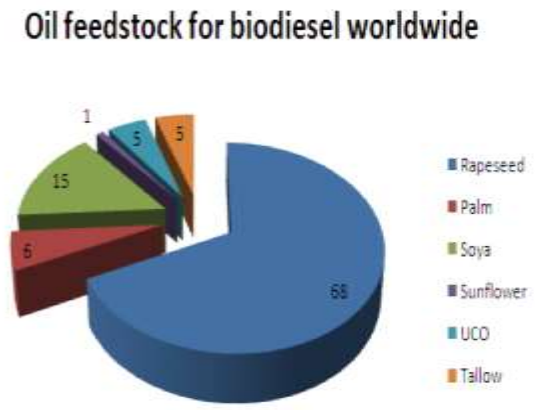


Fig.2: Oil feedstock for biodiesel worldwide

Properties of Waste cooing oil

Table-1: Properties of Waste cooking oil

Name of Properties	Sample 1	Sample 2	Sample 3
FFA%	0.57	1.15	1.25
Kinematic Viscosity at 40 °C Mm²/S	37.656	38.67	34.606
Viscosity at 40 °C	35.396	37.509	33.429
Density at 27 °C g/ml	0.94	0.97	0.966
Carbon Residue, Wt%	0.33	0.36	0.4

5. Production of Biodiesel

Methodology

Equipment and apparatus required for the laboratory scale production of biodiesel:

- Magnetic stirrer
- Helical condenser,
- Separating funnel,
- Three mouthed conical flask and conical flask, 5. Thermometer,
- Stand for separating funnel and helical condenser,
- Rubber tubes for supply of water,
- Weighing balance
- Beaker and filter paper for filtration of waste cooking oil.

preparation of biodiesel from waste cooking oil (laboratory scale)

Waste cooking oil is collected from two different domestic sources in Bhavnagar and named as sample I, II respectively. The waste cooking oil is filtered using a filter paper. Filtration of waste cooking oil is shown in below figure.

Fig.3: Filtration of Waste cooking oil

- **Experiment-1**

- 100 ml Waste cooking oil sample-1, 20 ml of methanol, and 1 gm of sodium hydroxide was taken. Methanol and sodium hydroxide is mixed with the help of magnetic stirrer. Sodium hydroxide is completely dissolved in methanol, using magnetic stirrer.[37]
- The oil sample is heated in reactor at 55-65 °C. using heating mantle.
- After oil reached to the set temperature, methanol & catalyst is added. reaction time is 1 hour 30 min.[38] After the solution is added to the beaker, because glycerol is the very viscous, so settle at bottom.[39] Solution taken in the beaker. Separation time is 1 hour and after one hour clear two layers are achived. The layers are separates.[40]

Fig.4: Preparation of Biodiesel from Waste cooking oil.

Fig.5: Produce biodiesel and Glycerol

Fig.6: Separation and Washing process

6. Find the Properties of Biodiesel

6.1 Density of biodiesel

Find the density of any liquids using the specific gravity bottle.[41]
Density of biodiesel= (Wt. of blank bottle- Wt. of loaded bottle)/ 25

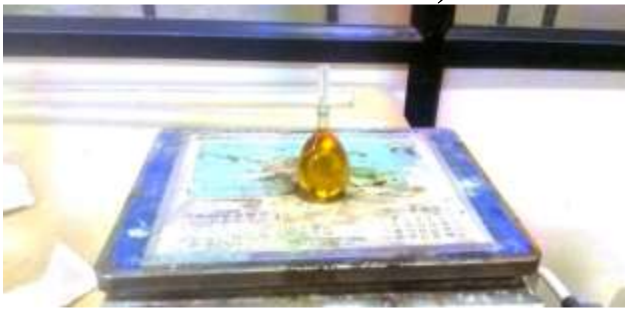


Fig.7: Specific Gravity bottle

6.2 Viscosity and kinematic viscosity

Find the viscosity of any oil and liquid, we can use the redwood viscometer.[42]

Fig.8: Redwood viscometer

We can find the kinematic viscosity is standard equation are given below:

Y= 0.254(X)-2.224
Where
Y= Kinematic Viscosity in Centi stock
X= Time in Second.
μ= Y*δ
Where
δ= Density of our liquid g/ml
μ= Viscosity in cp

6.3 Flashpoint

Find the Flash point of biodiesel by using Cleveland equipment.[43] This equipment is shown in figure.

Fig.9: Cleave land Apparatus

Table-2: Properties of waste cooking oil

Name of properties	Sample-1	Sample-2	Sample-3
FFA%	0.57	1.15	1.25
Kinematic Viscosity at 40 ºC, cst	37.656	38.67	34.606
Viscosity at 40 ºC, cP	35.396	37.509	33.429
Density at 27 ºC, g/ml	0.94	0.97	0.966
Carbon Residue,wt%	0.33	0.36	0.4

Table-3: Properties of Biodiesel from Waste cooking oil.

Name of properties	BD from S-1	BD from S-2
Density at 27 ºC, g/ml	0.84	0.87
Kinematic viscosity at 40 ºC, cst	5.632	5.109
Viscosity at 40 ºC, cP	4.7308	4.44
Flash point ºC	125	127
Calorific value MJ/kg	45.53	46.48
Cetane number	53.67	54.98

Table-4: Properties of biodiesel from waste cooking oil (Sample-3)

Name of Properties	Exp.1	Exp.2	Exp.3	Exp.4	Exp.5
Density at 27 ºC, g/ml	-	0.899	0.85	0.88	0.90
Kinematic viscosity at 40 ºC	-	13.016	8.698	8.232	7.936
Viscosity at 40 ºC	-	11.70	7.393	7.244	7.1424
Flash point ºC	-	127	129	126	124
Calorific value MJ/kg	-	47.82	47.14	47.10	47.00
Cetane	-	58.12	58.09	57.90	57.32

number					

Table-5: Properties of biodiesel and diesel (from literature)[44][45][46]

Name of properties	WCO Biodiesel	Diesel
Density (20 ºC) kg/m³,	889	837
Cetane Number	51.62	59.47
Heating Value, MJ/kg	39.48	45.856
Kinematic Viscosity (40 ºC) mm2 /s	4.75	2.76

Conclusion

It is concluded that production of biodiesel from any WCO samples with the help of methanol and sodium hydroxide. Reaction time is kept 3 hours. Methanol to oil ratio 1:5. Biodiesel is produce from different samples of domestic waste cooking oil.

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