BIODIESEL PRODUCTION FROM MIXTURE OF THREE NON-EDIBLE OILS AND EMISSIONS ANALYSIS IN CI ENGINE

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ABSTRACT —Biodiesel, an alternative diesel fuel, is made from renewable biological sources such as vegetable oils and animal fats. It is biodegradable and non-toxic has low emission profiles and so is environmentally beneficial. In this study instead of using a single oil as feedstock ,it was tried to use a mixture of three different source oils as a new source of biodiesel production which is a good approach owing to feedstock shortage in production of biodiesel. In this work attempt has been done to produce biodiesel from a mixture of three non edible feedstock namely *Jatropha (Jatropha cucus), Nahor (Mesua ferrea linn) and Castor (Ricinus communis).* Here, these three mixture oil mixed in different proportions. The properties of produced biodiesel were found to be within the standard limits defined by ASTM. In order to determine the potential of the biodiesel as a fuel and perform emission studies, different blends were prepared and studied using a standard diesel engine set up. With the increase of the engine speed, HC, CO and NOx emissions were found to be decreased. From the emissions point of view B30,B40 and B50 blends were found to be suitable blends , because they had a very less emissions then the other fuel samples.

Index Terms- **Biodiesel, Transterification , Blending, IC engine, Emissions .**

I. INTRODUCTION

At present ,the world's energy needs are met through non-renewable resources such as petrochemicals, natural gas and coal. Since the demand and cost of petroleum based fuel is growing rapidly, and if the present pattern of consumption continues, these resources will be depleted in few years. Hence, efforts are being made to explore for alternative source of energy. An alternative fuel must be technically feasible, economically competitive, environmentally acceptable and readily available [1]. Vegetable oils have attracted attention as an alternative for petroleum based fuel [2]. Due to high viscosity and low volatility of raw vegetable oils, its long term use in engine caused different problems such as deposition, ring sticking and injector choking inside the engine [3]. Hence, improvement in the vegetable oil was foreseen to improve the quality of the fuel. The methods used to reduce viscosity are - blending with diesel, emulsification, pyrolysis, transesterification [4-5] Among these, the transesterification is the commonly used commercial process to produce clean and environmental friendly fuel. Transterification is a process of producing biodiesel. Here vegetable oil react with alcohol in the presence of catalyst like NaOH, KOH etc , which produce Biodiesel and Glycerin. Glycerin can be easily separated from the final product and Biodiesel can be obtain. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. [6]. There are two methods of transterification process for production of biodiesel. Those are based catalyst transterification and acid catalyst transterification. Base-catalyzed transesterification, however, has some limitations among which are that it is sensitive to FFA content of the feedstock oils. A high FFA content (> 1 % w/w) will lead to soap formation which reduces catalyst efficiency, causes an increase in viscosity, leads to gel formation and makes the separation of glycerol difficult. Also, the oils used in transesterification should be substantially anhydrous (0.06 % w/w). The presence of water gives rise to hydrolysis of some of the produced ester, with consequent soap formation.There is a limitation of base-catalyzed transesterification is its sensitivity to the purity of the reactants, especially to moisture and FFA content. Acid catalyst transesterification of triglycerides is usually catalyzed by inorganic acids such as sulfuric acid, hydrochloric acid, phosphoric acid and sulfonated organic acids[7].

The main advantage of biodiesel is its potential for reducing greenhouse gases emission and efficient performance in existing diesel engine. The Chemical composition of biodiesel is different from the petroleum based diesel fuel. Biodiesel hydrocarbon chains are generally 16-20 carbons in length and contain oxygen at one end. Biodiesel contains about 10% oxygen by weight. It does not contain any sulphur, aromatic hydrocarbons, metals and crude oil residues. These properties improve combustion efficiency and emission profile. Its fuel blends reduce particulate material (PM), hydrocarbon, carbon monoxide and sulphur oxides. However, NOx emissions are slightly increased depending on biodiesel concentration in the fuel [8].

The purpose of this works is to investigate the effect of used mixing of vegetable oil feedstocks on methyl ester formation and the optimum ratio of biodiesel production and the new vegetable oils which are used as feedstock for alkali-catalyzed transesterification under the same optimum conditions of the new vegetable oils. This blended feedstock will be an alternative source of lower-cost biodiesel for future use. For this purpose Jatropha (Jatropha curcas) , Nahor (Mesua ferrea linn) and Castor (Ricinus communis) seeds were used as a mixed feedstock of biodiesel production.

II. MATERIALS AND METHODOLOGY

2.1. Materials

Jatropha) Jatrpha curcas(seeds were collected from the local suppliers of Hojai ,Nogaon district ,Assam. Nahor) Mesua ferrea linn(and Castor) Ricinus communis(seeds were collected from the Sivasagar and Sonitpur district, Assam. All the seeds were collected during the month August-September ,2010. The oils were mechanically extracted from the seeds using a screw press in the mechanical expeller and then settled until impurities were precipitated. All chemicals used in the experiments such as methanol, sodium and potassium hydroxides , H_2SO_4 etc were procured from local suppliers.

2.2.Methodology

Different oil mixtures were prepared in the ratio of 50:30:20 (Jathropha:Nahar:Castor)[sample A] ; 60:40 (Jatropha : Nahor)[sample B], 60:40 (Jatopha: Castor) [sample C] and 60:40 (sample Nahor : Castor) [D] respectively. The acid value of the mixture of oils was found to be considerably high so pretreatment was necessary prior to the transesterification reaction.

Because of high FFA(Free Fatty Acid), both steps (acid and based catalyst tranterification) of the biodiesel production process from the three seeds oil (Jatropha , Nahor and Castor) were carried out in a 500 ml two or three-necked round-bottomed flask equipped with a reflux condenser . The reaction flask was placed on the plate of a magnetic stirrer (400 rpm). The temperature was maintained at around 60^0C .

Acid catalyzed esterification (Pretreatment)

A 500 ml two necked round bottom flask was used as a reactor. The oil mixture was poured into the flask and heated. The solution of conc. H_2SO_4 acid (1.0 or 2.0% based on the oil weight) in methanol was added to the flask. The molar ratios of methanol to FFA of the oil was maintained at 6:1 and the reaction was carried out for 3 hours from the start at 60 °C. The final reaction mixture was poured into a separating funnel. The lower layer (oily phase) was separated , dried and used for further processing by the Based catalyzed Transesterification .

Based catalyzed Transesterification

The acid pretreated oil was poured into the reaction flask and heated. The solution of NaOH in methanol (1% based on the oil weight) was thermostated at 60°C and then added with the pretreated oil. The molar ratio of methanol-to-pretreated oil was 6:1. The reaction mixture was stirred by a magnetic stirrer. Heating and stirring were continued at atmospheric pressure. After the reaction, the product was allowed to settle under gravity in the separating funnel where it was separated into two layers. The upper layer consisted of methyl esters, residual methanol and catalyst, and impurities, whereas the lower layer contained a mixture of glycerol, excess of methanol, catalyst and impurities. The glycerin layer was drawn off and the methyl ester layer was then washed gently with hot distilled water at 60°C. The wet biodiesel was then dried at 100°C in the oven . Finally, the methyl ester content in the biodiesel product was determined .

III. RESULTS AND DISCUSSION

3.1. Feedstock and biodiesel analysis

Characterization was done for the all the feedstock mixed in different ratio. High acid value of 16.9, 13.5, 15.0 and 16.4 were obtained for sample A, B, C and D respectively. This indicates that the feedstock must undergo two stage transesterification in order to produce biodiesel. GC-MS analysis (table 1) was carried out to obtain the fatty acid compositions for feedstock employed.

Table 1. Major Fatty acid composition of mixed feedstock (sample A)

Fatty Acid	Retention Time/min	Chemical Formula	Fatty Acid (%)
Stearic acid	**8.25**	$C_{18}H_{36}O_2$	**16.34**
Palmitic acid	**9.89**	$C_{16}H_{32}O_2$	**14.50**
Palmetoleic acid	**13.22**	$C_{16}H_{30}O_2$	**0.11**
Archidic acid	**18.21**	$C_{20}H_{40}O_2$	**0.57**
Myristic acid	**7.72**	$C_{14}H_{28}O_2$	**0.15**
Linoleic acid	**13.49**	$C_{18}H_{32}O_2$	**17.25**
Oleic acid	**18.10**	$C_{18}H_{34}O_2$	**46.86**

3.2. Fuel characteristics of Biodiesel from the mixture of different seeds oil

The biodiesels produced from the mixtures of vegetable oil (Jatropha Nahor and Castor oil , (and at the optimum blending ratio were sent to Quality Control Division of) Numoligarh Refinary LimmitedNRL ,(Assam to determine their properties by using standard test methods. The fuel properties of biodiesels obtained from these mixtures of oils and diesel are summarized in table 2.

Table 2. Fuel properties of biodiesel obtained from three mixtures of oils and diesel obtained from NRL, Assam,India.

Parameters	**Unit**	**C+N(4:6) [D]**	**C+J(4:6) [C]**	**J+N(6:4) [B]**	**J:N:C(5:3:2) [A]**	**Diesel**
Density@15°C	gm/cc	0.882	0.881	0.878	0.880	0.852
S- Content	% wt	0.003	0.0095	0.005	0.007	0.016
Viscosity@40°C	cst	4.850	4.850	4.400	4.690	2.781
Flash Point	°C	>110	>110	>110	>110	49
Pour Point	°C	(-)4.0	(-) 3.0	(-)3.0	(-)4.0	0
Calorific value	kJ/g	39.500	39	40	40.250	45.083
Cetane number		-	-	-	52	46
Carbon residue	% wt	0.056	0.039	0.048	.088	0.011
Cloud Point	°C	4	3	3	5	(-18)

Where ,J = Jatropha oil , N = Nahor oil, C= Castor oil

3.3.Specification of the Engine Setup

Product : Engine test setup 4 cylinder , 4 stroke , Diesel Engine (computerized)

Product code : 228

Engine : Make Telco , Model Tata Indica , Type 4 Cylinder, 4 Stroke, Diesel water cooled ,Power 39 kW at 5000 rpm, Torque 85 Nm at 2500 rpm ,stroke 79.5 mm, bore 75 mm, 1405 cc, Dynamometer : Type eddy current , water cooled, with loading unit.

Fig.1. Engine test setup (computerized)

3.4. Emissions characteristics of the fuel

Exhaust emissions like CO , CO_2 ,HC and NOx were measured with the help of a exhaust gas analyzer and the results were analyzed with the speeds. All experiments were performed with the use sample A.

(a) Carbon monoxide (CO) emissions

Among the various pollutants of air CO is considered as the most harmful one. A substantial percentage of CO present in air is due to its emission from incomplete combustion of fossil fuels in vehicles.

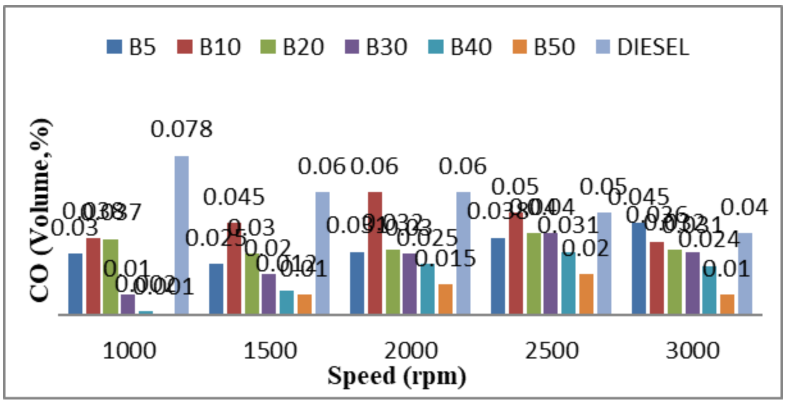

Fig.2. CO Emissions vs speed

CO emissions of the petroleum diesel , B5 ,B10 ,B20, B30,B40 and B50 are shown in the Fig.2. From the figure it is seen that at all the speeds diesel showed higher CO emissions then the other fuel samples and B30, B40, B50 blends showed lower CO emissions then the other fuel samples. Hence it can be observed that the higher the engine speed, the lower the CO emissions for all of the fuels. This may be due to the better mixing of air and fuels at higher speeds for higher turbulence. The higher the biodiesel percentage in biodiesel–diesel blends, the lower the CO emissions. This could be due to higher O_2 concentration in the air–fuel mixture, which can improve combustion and enhance further CO oxidation. From pollution point of view , all blends were found to be much superior than the petroleum diesel.

(b) Carbon di oxide (CO_2) emissions

CO_2 emission characteristics of petroleum diesel , B5 ,B10 , B20 ,B30,B40 and B50 are shown in the Fig.3. From the figure it is observed that diesel showed higher CO_2 emissions at all the speeds. CO_2 emission was found to be increase of the blends B5,B10 and B20 but its emissions level is lower than the diesel fuel sample. Higher CO_2 emissions is a indication of the complete combustion of fuel. That means the higher value of exhaust gas temperature.Hence higher percentage of biodiesel blends showed the lower emissions because of the reason of incomplete combustion of fuel.

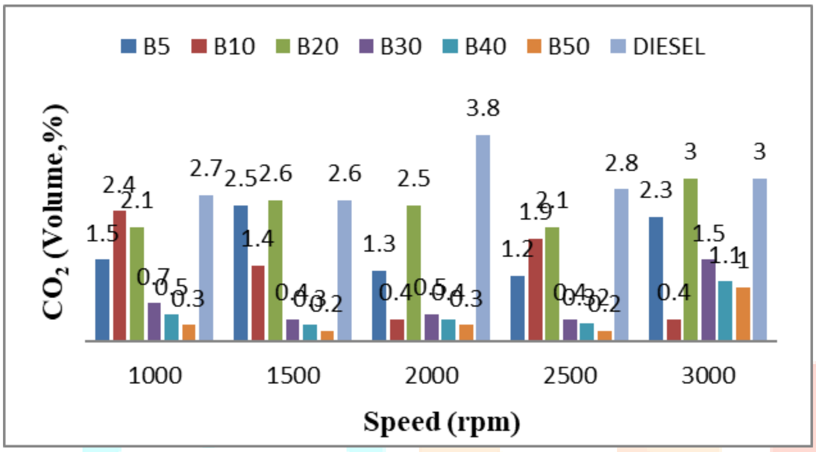

Fig.3. CO_2 Emissions vs Speed

(c) NOx emissions

Emissions of NOx are shown in the Fig.4 for different blending with different speeds. From the figure it seens that with the increase of the speeds NOx emissions decreases for all fuel samples. This may be attributed to the shorter residence time/ignition delay available for NOx formation at higher speeds[9]. Again B30, B40 and B50 showed the lower NOx emissions at all the speed.It may be due to light load operation at this stages and with these blends. At light load operations, the engine runs at a very lean state.

. Extra O_2 in biodiesel in this case does not help to produce higher NOx, because the mixture is already very lean[10].

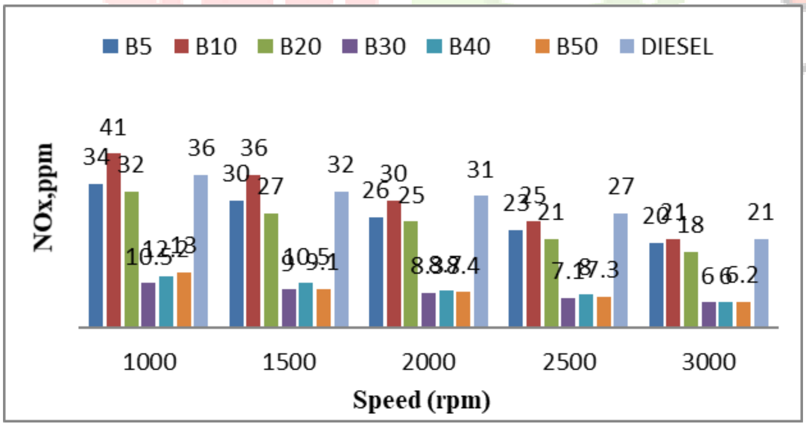

Fig.4.NOx Emissions vs Speed

(d) HC emissions

HC emissions are shown in the Fig.5 for different blending with different speeds. It seen that at all the speeds emission of HC for diesel fuel was found to be higher for all fuel samples. But it is observed from the figure that HC emissions decreased as the speed of the engine increased for all the fuel samples. This may be due to better mixing of fuel and air at higher engine speeds. And also B20,B30,B40 and B50 showed the lower emissions of HC at all the speeds that is the higher the biodiesel percentage in biodiesel–diesel blends, the lower the HC emissions. This may be due to the fact that the higher O_2 concentration in the air–fuel mixture can help enhance oxidation of unburned hydrocarbons.

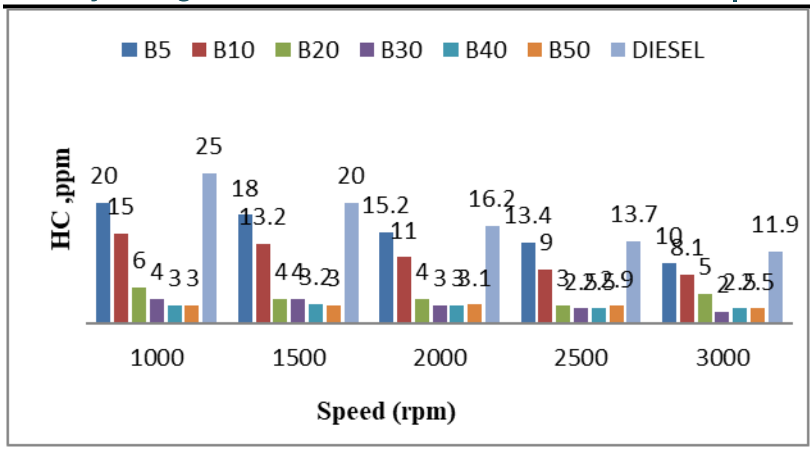

Fig.5. HC Emissions vs Speed

IV. CONCLUSION

In the study instead of using a single oil as feedstock ,it was tried to use a mixture of three different source oils as a new source of biodiesel production which is a good approach owing to feedstock shortage in production of biodiesel. In this work attempt has been done to produce biodiesel from a mixture of three non edible feedstock namely *Jatropha cucus, Mesua ferrea* and *Ricinus communis*. The properties of produced biodiesel were found to be within the standard limits defined by ASTM. In order to determine the potential of the biodiesel as a fuel and perform emission studies, different blends were prepared and studied using a standard diesel engine set up. From the emissions point of view B30,B40 and B50 can be considered as a suitable blends , because it has a very less emissions then the other fuel samples at different speeds.

From the results of the present study, it is evident that the mixture of seed oils from jatropha , nahor and castor can be used as the source of feed stocks for biodiesel production. . The neat biodiesel produced from the mixture by transterification process do not meet all the required fuel characteristics as per ASTM standards for petro-diesel. Hence each of these biodiesel needs to be blended with the petroleum diesel to achieve the required specification.

For commercial production of biodiesels from mixture ofnon - edible plant oils in large scale plantation of Jatropha, Nahor and Castor tree in waste land and roadside should be taken up.

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VI. REFERENCES

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