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ENVIRONMENT FRIENDLY TRANSESTERIFIED BIO FUEL FOR DIRECT INJECTION (DI) DIESEL ENGINE

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Abstract-The increased power demand, depleting fossil fuel resources and environmental pollution have led the world to seriously think for the alternative source of energy. The main reason behind to switch over to these alternative resources are sustainability, renewability and pollution reduction. In India, the energy generation is around 70% from fossil fuels, i.e., coal, crude oil, natural gas, etc. in which 80% is imported. Due to limited oil reserves, India depends on substantial imports for fulfilling its present and future needs. The higher viscosity of the vegetable oils compared to diesel resulted in significantly different atomization and injection characteristics of vegetable oils from those of diesel fuel. The high-viscous oils caused injector coking and contaminated the lubricating oil and resulted in poor engine performance. In the present to overcome these problems vegetable oil is converted to biodiesel using transesterfication process for reducing the viscosity of vegetable oil and can use in diesel engine without any engine modifications. In this research work the optimization of amount of alcohol, amount of catalyst, reaction temperature are analyzed. The experimental results showed that 20% methyl alcohol, 0.5% $NaOCH_3$ catalyst and reaction temperature of 55 °C gives the maximum biodiesel yield.

Keywords: Diesel engine, vegetable oil, transesterification, catalyst, reaction temperature, atomization,viscosity.

1. INTRODUCTION

The need for energy is increasing day by day with the increase of population and demand for energy for comfort living. Worldwide, every country is facing power deflect; the crisis is more critical among the developing nations. Sanjib Kumar Karmee & Anju Chadha (2005) prepared biodiesel from crude pungam oil by using KOH as catalyst and methanol. The conversion was 92% at 600°C with 1:10 molar ratio (oil : methanol) for KOH (1% by wt) catalyzed transesterification.
The fuel properties compared well with accepted biodiesel standards, i.e., ASTM D6751 and German biodiesel standards DIN 51606. Yasufumi Yoshimoto and Masayuki Onodera (2002) investigated the engine performance, combustion characteristics and exhaust emissions with vegetable oil-diesel fuels of blends and various fuel-improving agents to improve the oil viscosity and distillation characteristics in a single cylinder DI diesel engine. Rapeseed oil and eight kinds of oxygenates, such as ethanol, propanol, 1-butanol, 1-pentanol, 2-methoxyethanol, 2-ethoxyethanol, 2-butoxyethanol and di-butyl ether with lower boiling points and higher volatility were tested. It was observed that all the

above oxygenates except ethanol and 2-methoxyethanol had good solubility in rapeseed oil (by manual mixing) at room temperature. The smoke emissions with ether oxygenate blended in rapeseed oil decreased linearly with increase in the oxygen content of the fuel.
It was also observed that with up to 33% (vol.) of oxygenate addition-blended fuels with 2-ethoxyethanol, 2-butoxyethanol or dibutyl ether realised stable combustion similar to diesel operation.

Lakshmi Narayana Rao et al (2004) investigated the use of unrefined rice bran oil, coconut oil and neem oil in a 4.4 kW DI diesel engine. The brake thermal efficiency was found to be lower for vegetable oils compared to diesel. CO and UBHC emissions were found to be slightly higher than diesel but NO_x emissions were found to be lower. They concluded that the sluggish combustion and increased fuel consumption were due to lower calorific value and poor atomization.Mohanty et al (2011) evaluated the combustion, performance and emission characteristics of a diesel engine using blends of polanga oil and diesel. Their results showed that the BTE of polanga oil was slightly lower and the emissions of CO, UBHC were lower while the NO_x emissions were higher compared to diesel. They concluded that vegetable oils are very good alternative fuels and have great potential for use in diesel engines because of their abundant availability, renewable nature and lower emissions. Hanbey Hazar & Hüseyin Aydin (2010) investigated how vegetable-based oils can efficiently be used in compression ignition engines. Results showed that preheating of raw rapeseed oil reduced its viscosity and provided smooth fuel flow and avoided fuel filter clogging. Preheating of the fuel was seen to have some positive effects on engine performance and emissions when operating with vegetable oil.

Cvengro & Povaz (1996) described biodiesel production by using two-stage low-temperature transesterification of cold-pressed rapeseed oil with methanol at temperatures up to 70°C. The molar ratio of methanol to oil was 4:1 and 4% NaOH in methanol was used as the catalyst. The critically different aspect in this study was the final treatment of methyl ester with phosphoric acid and ammonia which provided for an exchange of soap formed in methyl ester for ash-less form, thus rendering methyl ester non-corrosive. Edward Crabbe et al (2001) studied the effect of three principal variables, molar ratio of methanol to oil, amount of catalyst and reaction temperature, on the yield of acid-catalyzed production of methyl ester (biodiesel) from crude palm oil. The biodiesel was then used as an extractant in batch and continuous acetone–butanol–ethanol fermentation, and its fuel properties and that of the biodiesel were analyzed. The optimized variables, 40:1 methanol/oil (mol/mol) with 5% H_2SO_4 (vol/wt) reacted at 95 °C for 9 hours, gave a maximum ester yield of 97%.
Transesterification, also called as alcoholysis, is chemical reaction of an oil or fat with an alcohol in the presence of a catalyst to form esters and glycerol. It involves a sequence of three consecutive reversible reactions where triglycerides (TG) are converted to diglycerides (DG) and then DG are converted to monoglycerides (MG) followed by the conversion of MG to glycerol. In each step, an ester is produced and thus three ester molecules are produced from one molecule of TG. Methanol and ethanol are used most frequently and methanol is preferred because of its low cost. A catalyst is usually used to improve the reaction rate and yield. Because the reaction is reversible, excess alcohol is used to shift the equilibrium to the product side. It also gives glycerol as a byproduct, which has a commercial value.

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2.PRODUCTION OF COTTONSEED OIL METHYL ESTER (CSOME)

The transesterification process of CSO was performed using 5 g sodium methaoxide as catalyst and 100 ml methyl alcohol per 1 L of CSO. The CSO was heated to 70^{o}C in a reactor of capacity of 40 L. The catalyst was mixed with methyl alcohol and added to the heated CSO in the reactor. After the mixture was stirred for 1 h at 70^{o}C, it was transferred to another container to separate the glycerol layer. Once the glycerol layer settled down, the methyl ester layer, formed at the upper part of the container, was transferred to another vessel. A washing process was carried out using distilled water and blown air to remove some unreacted methanol and catalyst. A distillation process at 110^{o}C was applied for removing the water contained in the esterified cottonseed oil. Finally, the CSOME was left to cool down..The chemical equations of transesterification process is given in Figure 1. The CSO used for the process, CSOME formed after transesterification and the by product glycerol formed in the process are shown in Figure 2.

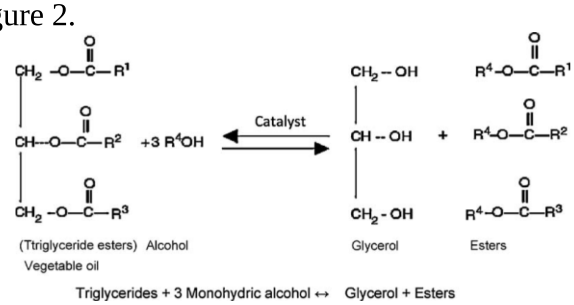

Fig.I. Chemical equation of transesterification process

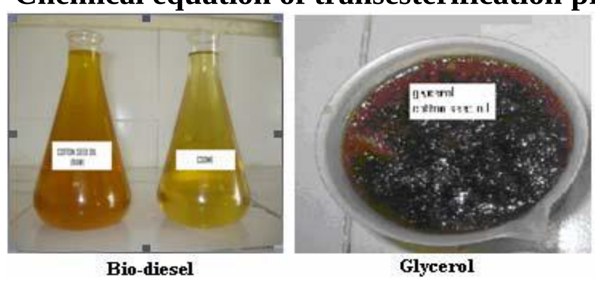

Fig.II.CSO, CSOME and glycerol

III. RESULTS AND DISCUSSION

Optimization of Various Parameters for Transesterification

The high viscosity, low volatility and polyunsaturated character of the triglycerides create problems when substituting them as fuels for diesel engines. The problems have been solved by developing vegetable oil derivatives that have properties close to those of diesel by heating of vegetable oils, blending, thermal cracking, micro-emulsion and transesterification. Among the different vegetable oils, attention is focused on non-edible kind of oils for the investigation. Cottonseed oil, Jatropha oil and Used Cooking Oil are considered in this research for use in diesel engines. transesterification of vegetable oil has done to reduce the viscosity of oil.

The most important variables for optimization considered for transesterification in this

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research are the following:

(i) Amount of alcohol
(ii) Amount of catalyst
(iii) Reaction temperature

Optimized Parameters for Biodiesel Production

Methanol was chosen for this research because it can be commercially obtained in anhydrous form. The amount of methanol needed also varies but it is ideal to use the least amount of methanol necessary to get the highest yield. Figure 3 shows the effect of methanol percentages and reaction temperature for production of Cottonseed oil methyl ester. The volumetric percentage of methanol was varied from 15 to 25%.

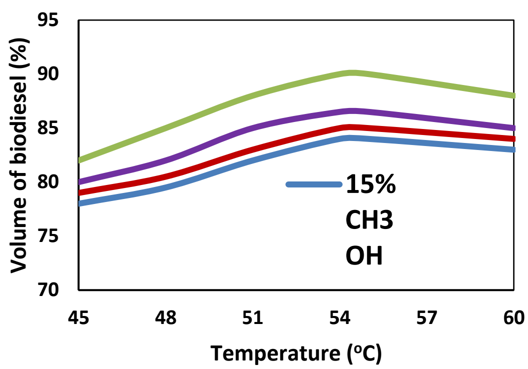

Fig.III.Effect of Temperature on Biodiesel Production ($NaOCH_3$ = 0.5%)

The increase in reaction temperature from 45 to 60 °C resulted in an increase in the yield of biodiesel but beyond 55 °C, the yield is observed to decrease. Hence, reaction temperature of 55 °C is selected. It is observed that percentage of methanol of 20 gives the maximum yield at a temperature of 55 °C. Figure 4 shows the effect of weight percentage of catalyst ($NaOCH_3$) on the yield of biodiesel. It is observed that reaction temperature of 55 °C with 0.5% $NaOCH_3$ as catalyst gives the maximum yield. Percentage of catalyst required was different for the three vegetable oils and the percentage yield was also observed to be different. Table 1 shows optimum values of transesterification variables for the three vegetable oils used.

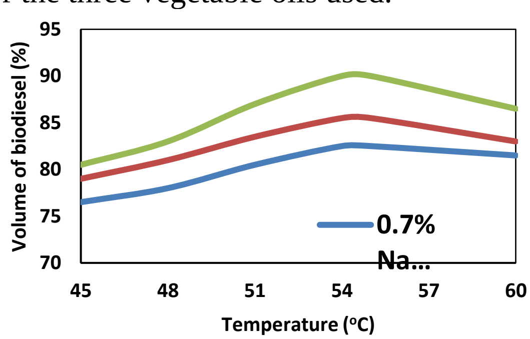

Figure 4 Effect of Catalyst ($NaOCH_3$) Percentages on Biodiesel (CH_3OH = 20%)

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Oil	Optimized variable			
	Reaction temperature (ºC)	**$NaOH_3$ (%)**	**Molar ratio of methanol to oil**	**Yield (%) (Volume basis)**
Cottonseed oil	55	7	6:01	90%
Jatropha oil	55	6.95	6:01	92.50%
Used Cooking oil	55	7.7	6:01	85%

Table 1 Optimum Values of Transesterification variables

Influence of Reaction Time on Biodiesel Production

Figure 5 shows the effect of reaction time on the yield of biodiesel. The catalyst percentage was set at 0.5%, methanol 20% and the reaction temperature was kept at 55 °C. It was found that when reaction time increases, the biodiesel production increases and reaches maximum at about 8 h. Reaction time of 8 h was best suited and gave a maximum production of biodiesel of 80%.

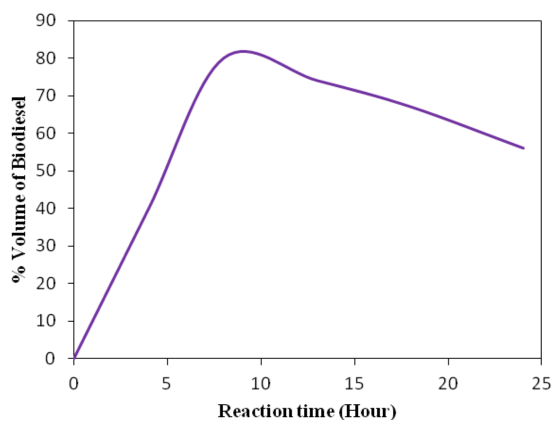

Figure 5 Effect of Reaction Time on Biodiesel Production (CH_3OH=20%, $NaOCH_3$ = 0.5%, Reaction Temperature 55°C)

Conclusion

The experimental work summarized the following results

- ✓ Vegetable oil viscosity is decreased by transesterification process which is closure to diesel fuel viscosity.
- ✓ It is observed that percentage of methanol of 20% gives the maximum yield at a temperature of 55 °C.

- ✓ The experimental results showed that reaction temperature of 55 °C with 0.5% $NaOCH_3$ as catalyst gives the maximum yield.
- ✓ The problem of injector coking and contaminated the lubricating oil and resulted in poor engine performance is eliminated by transesterfication process.

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