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Investigation of Production and Evaluation of Mono Alkyl Esters in Compression ignition Engines

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Abstract : This article is based on review of biodiesel fuel for Compression Ignition engines. The depletion of fossil fuels increases day by day and it has become a mandatory for an alternative fuel to satisfy the demand energy. Many researchers and scientists have reported that the biodiesel is one of the most offered recourses because of its benefits and applications. The results that are obtained using different processes proved that performance and combustion characteristics of biodiesel in IC engines are more effective as diesel. The combustion characteristics of various biodiesel blend ratios with diesel were found to be the shorter ignition of the physical and chemical delay, higher ignition temperature and pressure, and combustion peak heat release. The evaluation process demonstrates the better outcome for BSFC and BTE at increased compression ratio. For any kind of biodiesel test fuels, varying in compression ratio decreases the emissions of hydro carbon and carbon monoxide while oxides of nitrogen emissions increases.
Keywords: Biodiesel, Transesterification, Retention Time, combustion, Gas chromatography / Mass spectrometry.

Introduction

Due to the depletion of fossil fuels, the demand of energy increases day by day. Thus to fulfil the demand of energy, Bio diesel becomes one of the most important available resources that blends with the diesel to provide the better performance in IC engines. Bio diesel is named for its high combustion efficiency, bio degradability and sustainability. Many researchers have proved that bio diesel lowers the green house gas emission on IC engines. The raw oil of Calophyllum inophyllum is transformed into Calophyllum inophyllum methyl ester known as biodiesel evolution in the attendance of standardized acid method. The substantial properties Kinematic viscosity, Calorific Value, Density, Fire point and Flash point, Cetane number were establish out for Calophyllum inophyllum methyl ester at various blends[1].In this study, fatty acid methyl esters production was carried out through chemical interesterification of jatropha oil among ethyl acetate more than potassium hydroxide method. Throughout this latest route of biodiesel creation, triacetin was yielded rather than water or glycerol. Triacetin is recognized as preservative which meanings as an anti-knocking cause for biodiesel in diesel engine[2].The alteration demonstrates that the long chain mono-alkyl ester beginning the beeswax is altered into tiny chain methyl esters by a two step transesterification result. The prime represents of acid catalysed esterification in which Methanol, Wax Esters and Concentrated Hydrochloric acidic is used to decrease the free fatty acids[3].The reduction of fuel minerals and continuously increasing vehicle population has direct to investigate for a suitable substitute fuel to accumulate the future desires satisfying the emission standards as well. While diesel engines release gases like oxide of nitrogen (NOx) and particulate matter to horrible altitude which are destructive to the atmosphere, the investigate revolve into much more applicable. Emulsified fuels have been established to be capable in dropping the emissions[4].

There are number of methods that were carried out to produce bio diesels. The main disadvantages of the bio diesel fuels are high viscosity and high density. However the problems can be lessened by one of the most effective methods called transesterification process. The main aspect of automobile industries is to develop an effective pollution free engines but the combustion of fossil fuels in engines pollutes the environment by emitting NO_x, HC, CO gases. These problems are resolved by the transesterified bio diesel fuels since it is bio degradable, emission less and environmental friendly. The scientists and researchers have investigated various quantities of pure oil and refined biodiesel extracted from vegetable oils such as rapseedoil,palmoil, soybean oil,jatropha oil,rubber seed oil,Pongamia oil,Jojoba oil,rubber oil,tallow ate (animal fat).

Production of bio diesel

There are number of techniques used for the production of bio diesel such as ultrasonic cavitations, microwave irradiation, hydro dynamic cavitations, response surface technology, two step reaction processes etc. Generally for the production of bio diesel, the process called transesterification is used. The authors claimed that the content of oxygen in jatropha oil improves the efficiency of combustion and reduces the emission of black smoke[5]. The author combines canola methyl ester, linseed methyl ester, rapeseed methyl ester, sunflower methyl ester and beef tallow ester in a batch reactor with sodium hydroxide, potassium hydroxide and sodium methoxide as catalysts. The authors investigated the effects of the pre-treatment of immobilized Candida antarctica lipase enzyme on soybean. The effects of methanol from crude palm oil in the presence of catalyst to produce the methyl esters[6, 7].

The production of biodiesel fuel from vegetable oils.Shieh uses the response surface technology for the production of bio diesel from soybean oil.Zhang uses the acid-catalyzing process to produce bio diesel from waste cooking oil. The authors proved that the bio diesel produced from this process is feasible with less complexity than the alkali-catalyzing process using non edible oil[8].The authors developed a transesterification process to convert the rubber seed oil to fatty methyl esters fuels in the presence of catalyst. The Pongamia pinnata is mixed and stirred continuously at 60^{o}c in the presence of potassium hydroxide as catalyst to produce bio diesel[9]. The prepared biodiesel from in the same year, process to convert the Jojoba oil to biodiesel by trans-esterification using methanol[10].The oxygen content of biodiesel is high and it is used for complete combustion process[11].The effect of investigated the modification of diesel engine is to produce complete combustion and reduced gas emissions[12]. Manyresearcherstested thealteration of engine components and optimization on diesel engine, the innovative methodology and instrumentation for measurement have to be executed when the diesel fuel is alternative completely by fatty methyl esters [13].The raw vegetable oils extracted from varioussources and it is to be used without any process of purification. Theextracted oilswere transformed to biodiesel by alkali metal catalytic and non metal catalytic methanol esterification methods[14].

Process of biodiesel preparation

1.Transesterification process

The transesterification process of various parameters are involved such as mechanism amount, methonal or ethanol to oil, reaction time, settling and separation of fatty acid methyl esters. The vegetable oil and NaOH (or) KOH are heated up to 60^{0}temperatures and maintained for 1 hour 10 mins. After heating for one hour they should be poured into decanter with methonal. Themixture is kept in a rotating protester at 200 rpm for 18 hrs and allowed to coldsubsequently. A stagnant period of 12 hrs was allowed for a formation of fatty acid methyl esters and glycerol as by product[15, 16, 17]. On the other hand,the effect of investigation that 90% of fatty acid can be extracted from the raw vegetable oils[18]. The quantity of yield (by weight) of several vegetable oil fatty acids is given in Table (1).

Table 1 Yield of fatty acid methyl esters of vegetable oils by trans-esterification process

S.No	Temperature k	Corn oil (%)	Sunflower oil (%)	Cotton seed oil (%)	Soya bean oil (%)
1	620	80.5	79.6	82.3	84.2
2	630	95.8	93.6	96.5	97
3	640	97.2	97	97.6	97.6

2. Biodiesel separation process

The required temperature to maintain at the end of the vigorous mixing by means of a mechanical stirrer fixed into the flask (50^0C to 60^0C).The soybean oil is heated up to 60^0c temperature and maintained for 1 hr 10 minutes. It is allowed to settle for one day for removal of water. Sodium hydroxide (NaOH) is added to methanol and stirred thoroughly to produce sodium methoxide as shown in fig (1). The prepared sodium methoxide is poured into the mixture and the mixture is heated to 55^0C and the whole reaction is maintained. After heating for one hour the oil should be poured into flask as shown in fig (2). The mixture was kept in a rotating agitator at 200 rpm for 18 hrs and allowed to cool subsequently[19]. A stagnant reaction period was allowed for the formation of Soya bean Methyl ester and Glycerol as shown in fig (3).

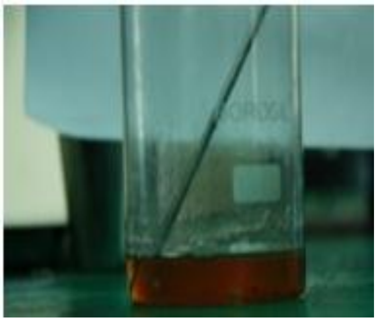

Figure 1.Methoxide solution

Figure.2 Mixture settling time

Figure.3 Extracted Biodiesel

3. Gas chromatography / Mass spectrometry

Knoth(2001) tested the raw vegetable or animal fatty acid methyl esters have been developed to instantaneous set on of glycerol, mono, di and tri-fatty acidusing of gas chromatography / mass spectrometry. The highly static-columns coated with a phases of polar stationary devoid of any chemical structure. The inattentiveness of the column, necessary to get good satisfactory recovery, minor and major peak shapes. Many reporters are analysed the use of the GC/MS for fatty acid methyl esters investigation utilize the spectrometric detector (MSD) and flame ionization method. These two methods would be getting rid of any intention about the surroundings of the prefer materials. The individual compounds has been obtained by from the time when massspectra Unique[20].

The data system of the JEOL GC MATE 2 GC MS is the capable of double focusing high resolution electron impact helium gas carriedgyy with a range of time from 60 to 600 ionizations by using GC/MS analysis. The system of JEOL GC MATE have been indentified the four major methyl esters depends on the fatty acids at retention time(RT) such as stearic acid at 10.23,palmitic acid at 9.2 , Niacin acid at 8.5 and Myristic acid at 8.09 [19].The common five major fatty acid esters found in common vegetable oils and animal fats. The amount of double bonds in the fatty acid chains has an extravagant effect on the properties of the transesterified methyl esters is given in Table (2). The distortion of the molecule sourced by double bonds reduces the biodiesel's gel temperature and the growth of crystals. Saturated fats have a propensity to gel at high temperatures. Fatty acid methyl esters have higher cetane numbers and improved oxidative stability, excluding will have poor cold flow properties[21].The fatty acid methyl esters extracted from oil trough trans-esterification process with less amount of saturated fats will have improved cold flow properties, but less amount of oxidative stability and cetane numbers[22].

Table 2 Fatty acid methyl ester for some common oils and fats

S.No	Vegetable oils and fats	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
1	Soya bean		4	25	55	8
2	canola	4	2	60	22	12
3	Rapeseed oil	3	1	13	14	10
4	Mustard	4	2	24	21	10
5	Olive oil	10	2	78	10	trace
6	Palm oil	44	5	40	10	trace
7	Tallow	28	22	42	4	trace
8	Yellow ease	20	18	54	8	trace
9	beef tallow	23.3	19.4	42.4	2.9	0.9
10	Coconut	9.8	3	6.9	2.2	0

The objective of this analysis to use the distance between the femoral head center and acetabular center on anteroposterior hip radiograph. There has been a minor peak at m/z 213.00 due to the misplace of carban and hydrogen atoms and there has been α ions expulsion and methoxy protons decaying at m/z 256.00[23, 24].

Performance of biodiesel

Fuel consumption, power yield, brake thermal efficiency of various mono alkyl esters had been reviewed by many researches and scientists. Yarbrough analysed the diesel engine performance with different ratios of sunflower oil and proved the prevention of engine failure. The experimental investigation results of rapeseed, sunflower and safflower oil, the performance of engine is found to be equivalent to diesel oil. The outcome shows that these vegetable oils cause some problems due to carbonization during long-term durability tests[25].This study suggested the rapeseed oil and canola oil as substitutes to diesel fuel in engines. The author specified that the performance of engine is better with canola oil and that the consumption of fuel is relatively high[26]. On the other hand,soybean oil used as a fuel in diesel engines and discovered that the bio diesel for running engines in long-term testing is quite tough due to the power loss and carbonization[27].the performance of biodiesel from rubber oil in a single cylinder diesel engine to be better in terms of low brake thermal efficiency, low emission rates and high combustion[28]. On the other hand, frying oil used to run a single cylinder diesel engine and found that the consumption of bio diesel is relatively high than that of diesel fuel[29]. The research scholar reported that the presence of oxygen content in mono alkyl ester improves the performance parameters of engine such as combustion efficiency but increases the fuel consumption[30].The effect of engine performance have proved that there is 18% increase in performance of engine when using mono alkyl esters from soybean oil and soap-stock[31].

Combustion of biodiesel

The combustion characteristics of the engines are evaluated by different authors in terms of ignition pressure, ignition temperature, ignition delay. The soybean oil is used to produce mono alkyl esters. The authors tested the blends of bio diesel fuel to run on a modified multi-cylinder, direct injection diesel engine with high volume and medium swirl type piston bowl and claimed that the blend ratio of bio diesel generated a very short ignition delay[32].Jojoba fatty acid esters used in a shock tube test and reported that the ignition pressure and ignition temperature increases and ignition delay decreases[33].The blend ratio of methyl tallow atewith diesel to run in the multi-cylinder, direct injection diesel engine and found to have lower heat emission than the normal diesel[34].The bio diesel fuel to test on diesel engine and claimed that the engine produces lower combustion duration than raw vegetable oil[35].The simulation technique is used to find the properties of cetane number in biodiesel fuel. The authors evaluated the fuel properties such as density, flash, viscosity of mono alkyl methyl esters and its variable blend ratios like B10, B15 and B20[36].Combustion helps in complete oxidation of the fuel molecules. The ignition delay increases as a result of high fuel consumption in combustion chamber. This accumulated fuel leads to high combustion pressure at the time premixed combustion phase. A slight variation in start of combustion which may be due to increased ignition delay is shown by combustion chamber[37]. The lower ignition delay as the soybean methyl esters blend is increased, poor and complex preflame reactions at all load and thermal cracking of SOME compounds which may undergo early ignition. If there is an increase in the blends of soybean methyl alkyl ester, rate of heat release reduces gradually with increase in loads which may be resulted due to lower volatility and higher viscosity[38,39].In this study observed the combustion characteristics of the blends of biodiesel fuel in a rail injection diesel engine. The result inferred that due to high viscosity and high surface tension, the size of the droplet increases[37, 40,41].

Emissions of biodiesel

In the observation of environmental issues, fatty acid methyl esters produce the lesser amount of carbon particles compare to the diesel fuel. The emissions of CO_2 level by methyl esters are acceptable range from the engine. It is Biodiesel mainly emits carbon monoxide, carbon dioxide,oxides of nitrogen, sulphur oxides and smoke. A succinct re-evaluate has made about these contaminants emitted from fatty acid methyl esters.The experimental investigated that, the mixture of peanut oil and sunflower oil with diesel fuel in single cylinder diesel engine. The high amount of vegetable oil blend ratios is increases the carbon deposition on the injector tip. The diesel fuel gave a higher mass based heating value than the vegetable oil blend ratios[42]. The fact that the bio diesel from rapeseed oil emits fewer amounts of smoke and NO_x .Scholl investigated that the engine run by soybean fuel produces less emissions of NO_x ,CO and HC when compared to diesel fuel.Ali on the other hand investigated the various methyl tallowate blends in a multi-cylinder diesel engine and discovered the fall in CO emissions[43]. The experimental deliberate that the rapeseed oil tested in diesel engines produces less HC emissions[44]. The exhaust gas recirculation technique on diesel engines and found a slight reduction in emissions of oxides of nitrogen[45].A relative reduction in the exhaust emissions for rapeseed bio diesel in single cylinder direct injection diesel engine[46].The experimental results reported that the single cylinder direction injection diesel engine is tested by fatty acid methyl esters such as sunflower oil, cotton seed oil, soy oil and corn oil[47].

The particle formation process of various alternative fuels such as compressed natural gas (CNG), dimethyl ether (DME), fatty acid methyl esters and diesel. The temperature of the different alternative fuels maintained at 800^0c to 1200^0 c with the approximate pressure of fuels 24 atm[48].The result displays that increase in emissions of CO for preheated mustard oil at different speeds[49].On the other hand exposed the highest emissions of NO_xdue to different combustion rates. They also observed reduction in other exhaust emissions[50].The blend ratio of bio diesel from sunflower oil to test on diesel engine and discovered a relative decrease in exhaust emissions[51].The extraction of biodiesel from olive oil in diesel engine and investigated a massive reduction in HC, CO, $NO_x$and smoke emissions[52]. The authors mentioned that the usage of olive oil methyl alkyl ester produce high combustion efficiency.

The unique investigated a single cylinder direct injection diesel engine with karanja bio diesel and concluded that the emission of oxides of nitrogen and CO is decreased[53].

The usage of rapeseed methyl alkyl ester in diesel engine and concluded that higher burning rates of bio diesel yields higher emissions of oxides of nitrogen[54]. The Cummins diesel engine produces higher emissions of oxides of nitrogen for different blend ratios of ethanol[55].

The bio diesel fuel blends ratios in diesel engine and experienced a significant reduction in emissions of particulate matters and raise in emissions of oxides of nitrogen.A slight variation in exhaust emissions for the soybean bio diesel in diesel engine[56]. Using the methyl alkyl ester of soybean oil in a large diesel engine produces significant reductions in the emissions of oxides of nitrogen, carbon monoxide and particulate matters. The result of the engine emits the high amount of No_x emissions compare to diesel fuel[57].The examined results the outcomeof additive antioxidants on the performance and emission categoryof engines fuelled with palm mono alkyl methyl esters and its blendsratios[58]. As per the ASTM specification, the blending ratio of B20 palm methyl esters have increased the addition of antioxidant such as viscosity, density and flash point as well as stability althoughdecreased the amount of calorific value.

Conclusion

Based on the investigation carried out by researchers, scientists and several engineers, 350 oil bearing crops are indentified and concluded that only few are potential biodiesels like rapseed, palm, jatropa and soya bean oil. Many experimental works have done by vegetable oil used as a fuel substitute in IC engines. It is analysed that biodiesel has similar fuel properties and combustion characteristics like as diesel. The presence of excess oxygen content in fatty acid esters improves the performance parameters of engine such as combustion efficiency but increases the specific fuel consumption. The thermal efficiency of the biodiesel is mostly similar to diesel with small amount of power loss while using raw vegetable oil. The fuel properties of mono alkyl methyl esters and its various blend ratio helps in providing complete oxidation of the fuel molecules during combustion. The emission characteristics of the hydrocarbon are more from the engine exhaust for the entire load with variable blend ratios. The emission of the ester blends releases more NO_X than diesel and the other engine exhaust emission of CO,HC,CO_2 were lower compare to diesel fuel. The use of biodiesel should be optimistic and it can contribute a very important role in helping the developed world to increase the pollution free environment.

Acronyms and Abbreviations

ASTM	American soc. For testing and Materials international
B10	Blend of 10 % biodiesel in petroleum diesel
B15	Blend of 15 % biodiesel in petroleum diesel
B20	Blend of 20% biodiesel in petroleum diesel
BSFC	Brake Specific Fuel Consumption
BTE	Brake Thermal Efficiency
CI	Compression Ignition
IC	Internal Combustion
CO	Carbon Monoxide
CO_2	Carbon Dioxide
NO_x	Oxides of Nitrogen
CNG	Compressed Natural Gas
DME	Dimethyl ether
SOME	Soybean oil Methyl Ester
NaOH	Sodium Hydroxide
RT	Retention Time
GC/MS	Gas chromatography / Mass spectrometry

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