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A Comprehensive Review of Effect of Biodiesel Additives on Properties, Performance, and Emission.

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Abstract. Objectives: -To presents the literature review on effect of biodiesel additives on properties, performance and on emission. Method:-In the current paper reviews are taken from previous years paper which necessitates the need of addition of additives in the blends of biodiesel and studied the its effect on properties , performance and emissions. Emissions from the diesel powered vehicles mostly damaged the earth's environment and also increased the overall earth's temperature. This attracts the need of alternative fuels in the field of transportation sector. Past inventions and research showed that Biodiesel can be used as an alternative fuel for the diesel engine. Biodiesel have good combustion characteristics because of their long chain hydrocarbon structure. However biodiesel possesses few disadvantages such as lower heating value, higher flow ability, much high density and not able to flow at low temperature. Higher rate of fuel consumption is identified and higher level of NOx emissions when biodiesel used in an engine as an alternative fuels. Findings:-Different additives such as antioxidants, improvers for cetane number, cold flow properties improver ,etc were investigated by the many researcher and scientists and added in the different feedstock of biodiesel or blends of biodiesel with diesel in different proportions. Directly or indirectly fuel additives can improve the reduction in the emissions, improve the fuel economy, and reduce the dependency of the one's nation on other. Performances of biodiesel vehicles were drastically improved because of additioninthe blends of biodiesel with diesel fuel in specific percentages to meet the international emission standards. Addition of additives in the biodiesel or in the blends of biodiesel basically changes the high temperature and low temperature flow properties of blends of biodiesel. Current paper finds and compares properties of different additives and its effect on blends of biodiesel properties, performance and on emissions from diesel engines. Improvement:-This paper presents the literature review on effect of biodiesel additives on properties, performance and on emission.

1. Introduction

Diesel engines are largely used in the transportation sector. However the reserves of conventional fuels reduced day by day. Therefore many researcher and scientists are now investigating other sources of fuel as an alternative fuel to the conventional petroleum fuel [1]. Biofuels can be produced from animal fats, plant oils or waste from agriculture, hotel or from industry. One of the known alternative fuels is biodiesel. The ester of long chain FFA(free fatty acid) used with the help of transesterification process produced from non conventional raw feedstock such as vegetable oil, animal fat etc. During the transesterification process the methanol is added with KOH as a catalyst which forms methyl esters and residual as a glycerin [2]. Different feed stocks of plant oil and animal fats such as Jatropha oil, Soybean oil, Palm oil, Cottonseed oil, Waste vegetable oil, Marine fish oil etc are being investigated as an alternative

resource for conventional petroleum fuels [3]. Biodiesel is biodegradable and non toxic. The harmful emissions from biodiesel such as carbon and smoke were drastically reduced as compared to conventional petroleum [4]. But on the different side lowheating value, higher viscosity , higher density and poor cold weather flow properties such as cloud point , pour point and cold filter plugging point limits the use of biodiesel which tends to have poor atomization of fuel, injector clogging , narrow spray pattern of fuel in the combustion chamber and incomplete combustion [5-8]. Many researchers investigated that without doing modification in the standard engine, the fuel properties such as the high temperature and low temperature properties of biodiesel can be enhanced by using different fuel additives such as oxygenated additives, metal based additives, antioxidant additives, cold flow properties improver, lubricity improver additives and cetane number improver additives [9-10].The literature review emphasis mainly on use of different biodiesel additives on the properties of fuel , engine performance and engine emissions.

2. Biodiesel Additives

Additives play a very important role in meeting the international fuel standards and real time problems which are associated with biodiesel. With the help of additives the fuel properties can be enhanced and biodiesel in blend can be used with diesel in the vehicle which able to increase the performance and reduction in exhausts emissions from the engine. The selection of biodiesel additives is mainly based on different properties of additives such as flash point, fire point, viscosity, density, calorific value, solubility etc [11]. The use of additives in biodiesel also solves many technical problems which limits the acceptability of biodiesel as an alternative fuel in all conditions. Table 1 shows the different properties of biodiesel additives.

Table 1 Properties of different bio-additives.

Additive	Kinematic Viscosity at 40^0C (cst)	Density (kg/m^3)	Calorific value (kJ/g)	Cetane number	Flash point (^{0}C)	Ref.
Ethanol	1.14*	791*	27.33	5-8	-	12
n-Butanol	3.00	812	34.33	25	35	12
Diethyl Ether	0.22	712	33.89	25	-	12
Methanol	0.59	790	19.62		11	13

(*- measured at 20^0C)

Ethanol contains s 34% higher oxygen by weight. Biomass can be converted to the ethanol by using the process of fermentation from the different feedstock the ethanol can be produces such as sugarcane, sugar beet, sorghum, potatoes, sunflower, molasses, corn , wheat, cotton etc[14]. Oxygenated fuels are generated because of addition of ethanol in diesel fuels. Ethanol with diesel is also named as Diesohol. Many

investigators documented that addition of ethanol in small percentage in the blends of biodiesel increases the brake thermal efficiency, increases the rate of heat release, reduces the viscosity and reduces the smoke in the exhaust of the engine. Also the physical and thermal properties of ethanol-biodiesel –diesel blends improved drastically which helps the combustion [15].

Diethyl ether is also an oxygenated additive which is biomass based produced from the ethanol. It is colourless fuel. It possesses high volatility. It also have high tendency to respond to low temperature because of high flammability. It has high cetane index. But on the other side the heating value of diethyl ether is lower than conventional diesel. But it used to mix with biodiesel or diesel easily. It has good solubility characteristics. Many investigators reported that addition of diethyl ether with diesel–biodiesel blend improves the properties of the blend and enhanced the performance and reduced the engine pollutants[16].

In past few years n-butanol is also emerged as an additive for the biodiesel – blend because of its higher percentage of O2 content. It is also refer as 1-butanol and produced from fermentation of different feedstock of biomasses. It has straight chain with OH group and has lower hydrophilic nature. High cetane number, good solubility and higher heat content attract many researchers to consider n-butanol as an additive to biodiesel-diesel blends [16].

Due to the poor cold flow properties of biodiesel-diesel blend it is not possible to use the blend in cold weather condition without the additives. Methanol is also a very promising alternative additive higher level of oxygen which is basically responsible to enhance the rate of combustion in the cylinder. It is an analysis grade anhydrous ethanol of purity 99.7%. The latent heat of methanol is 1109kJ/kg, which is considerably higher than the conventional fuel [17]. Because of all such type of properties, methanol is the strong competitor as an additive in the biodiesel–diesel blend.

3. Additives and Fuel Properties

Investigators have documented their results which show improvement in the fuel propertiesofdifferent feedstock of biodiesel with diesel by using different additives in the blends.In[18] studied the properties of biodiesel with 5% addition of methanol as an additive and reported that addition of additive decreases the density of blend from 845 kg/m^3 to 829 kg/m^3, viscosity from 4.5 cSt to 3.3 cSt and flash point from 100^{0}C to 92^{0}C. In[19] investigated and reported the properties of cottonseed biodiesel with diesel with an addition of ethyl levulinate as additive, and found the significant improvement in low temperature flow properties of blend. The cloud point was lowered from 4-5^{0}C, the pour point 3-4^{0}C, and cold filter plugging point was reported as 3^{0}C. In[20]had done the analysis and study of effect of ethanol and butanol on the cyclic variation in the diesel engine. In[21]investigated the effect of kerosene and ethanol as an additive in the Mahua oil biodiesel. They reported that addition of kerosene and ethanol in the blend of B20 biodiesel drastically enhanced the cloud point and pour point. In[12] studied the engine performance and exhaust gas emission of blends of biodiesel with n-butanol and diethyl ether as an additive, in[16]studied the effect of n-butanol and diethyl ether as additives on engine characteristics of a multiplecylinder diesel engine fuelled with diesel–Jatropha biodiesel blend and reported that kinematic viscosity of blend changes from 3.36 cSt to 3.16 cSt, lower calorific value 43.69 to 43.10 MJ/kg and flash point was improved from 96.5 to 71.5^{0}C. Table 2 gives the effect of addition of additives on the fuel properties of feedstock of biodiesel.

TABLE 2 Fuel additives and fuel properties of different feedstock of biodiesel

Feed stoke of biodiesel	% of Additives	Density at 20 ^{0}C (kg/m^3)	Viscosity at 40 ^{0}C (cSt)	Flash point ^{0}C	Pour point ^{0}C	Cetane number	Calorific value (MJ/kg)	Ref
Palm oil (B20)	5% Ethanol	833	3.23	84.5	-	46	43.08	12
Palm oil (B20)	5% n-butanol	833	3.39	85.5	-	47	43.43	12
Palm oil (B20)	5% DEE	832	3.37	81.5	-	52	43.41	12
Jatropha Oil (B30)	10% ethanol	832.87	2.80	14	-3	50	39.93	22
Palm oil (B20)	2% Methanol	837	2.31	13	–	–	40.21	23
Palm oil (B20)	2% Ethanol	838	2.37	18	–	–	40.53	23
Palm oil (B20)	2% DEE	840	2.35	15	–	–	39.65	23
Neem oil (B100)		-	4.5	165	-	51	41	24
Neem oil (B100)	5% Ethanol	–	4.2	153	–	49	40.4	24
Rice bran oil (B100)		874.2	4.63	165	3	56.2	37.9	25
Rice bran oil (B100)	5% Ethanol	782	1.35	22	<_35	10	–	25
Cottonseed oil (B100)		871	5.28	-	-	51	-	26
Cottonseed oil (B100)	5% Ethanol	867	-	-	-	-	-	26

4. Biodiesel Additives Performance and Emissions

Researchers analyzed the effect of additives on the performance and the emissions from the engines. In[25] studied the performance of single cylinder 4S diesel engine with rice bran oil biodiesel with 2.5% ethanol as an additive, and reported that the 6.98% increase in BSFC for ethanol blend and increased in BTE up to 27.82%.In[27] studied the effect of additives on performance and on emissions when fueled with biodiesel, the investigation reported that there was a 9% increase in brake power, 6% lower BSFC and NOx,CO2 and Co emissions were reduced. In[28]reported performance of engine, exhaust emission and combustion and heat release of a common-rail diesel engine fueled with bio-ethanol as a fuel additive in coconut oil biodiesel blends.Paper reported that there wasa increase in BTE and BSFC when operated with additives. Emissions from the engine also lowered the NOx, smoke, carbon monoxide as compared to diesel. In[29]investigated that when the engine is fueled with soybean biodiesel with ethanol as a additive then emissions from the engine such as NOx, CO, CO2, PM reduces. In[30] tested the feedstock of biodiesel from

tall oil with magnesium and nickel based additives at various loads. They reported that BSFC was increased by 6%. Exhaust emissions from biodiesel with additives also decreases, CO was decreased by 64.28% and smoke by 30.91%. Also there was a significant reduction in the NOx level. In[31] studied the ethanol biodiesel and diesel blend at different proportion and at different temperature. Investigation shows that there was a significant reduction in the CO and HC but NOx started to increase at higher engine load. In[32]studied emission parameters of a diesel engine with methanol and ethanol as a biodiesel additive. NOx and PM were reduced from the engine when fueled with additives. Alcohol increased the carbon monoxide and hydrocarbon in the exhaust. In[33]investigated and analyzed the exhaust emissions from a CI engine operated with biodiesel and methanol as an additive. Investigation reported that there was a reduction in CO2 and NOx and PM[34]. All experiments were performed on the constant speed engine at different load.

5. Conclusion

The comprehensive study framed the effect of additives on the biodiesel properties, biodiesel performance and emissions when used as an alternative fuel in the conventional diesel engine. The following conclusions are drawn from this review. Different additives with more oxygen contents are available. If such type of additives added in to the blends of biodiesel with diesel then they can enhance the quality of combustion and leads to complete combustion. Diethyl ether, ethanol, methanol,and n-butanol can be used as biodiesel additive because of their higher oxygen content. The use of additive enhanced the performance of engine and reduced the BSFC. Emissions such as nitrogen dioxide carbon monoxide, particulate matter etc will be reduced when fueled with biodiesel additives.

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