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STUDY OF BIODIESEL BLENDS AND EMISSION CHARACTERISTICS OF BIODIESEL

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Abstract: Biodiesel is a renewable diesel replacement fuel that is manufactured from domestically produced oils such as soybean oil, recycled cooking oils, or animal fats [13]. To manufacture biodiesel, these fats and oils are chemically reacted with a short chain alcohol (such as methanol) and a catalyst to produce biodiesel and a glycerin co-product. Biodiesel can be used alone (B100) or blended with petroleum diesel in any proportion [13]. Biodiesel can be legally blended with petroleum diesel in any percentage. ASTM International develops specifications for conventional diesel fuel (ASTM D975). These specifications allow for biodiesel concentrations of up to 5% (B5). Low-level biodiesel blends, such as B5 are ASTM approved for safe operation in any compression-ignition engine designed to be operated on petroleum diesel. Biodiesel can be blended and used in many different concentrations, including B100 (pure biodiesel), B20 (20% biodiesel, 80% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel) and B2 (2% biodiesel, 98% petroleum diesel) [14]. This paper deal with the different reviews of the studies associated with the emissions properties of biodiesel. Various Studies showed pollutants like CO (Carbon monoxide), HC (Hydro Carbon), PM (Particulate matters) etc. can be reduced by using biodiesel blended with diesel. Increment in NOx emission has been a problem in biodiesel but it can be overcome by various methods like cetane no improver. Additives play a crucial role in minimizing NOx emission that could be a sigh of relief for the researcher who are opting biodiesel as an alternative fuel [28].

Keywords: Biodiesel, Blending, Emission, and GHS: Greenhouse gases.

I. INTRODUCTION

Due to the potential exhausting and increasing price of petroleum together with environment concerns caused by the combustion of fossil fuels, the search for alternative fuels has gained much attention [1-3]. Waste cooking oils, and non-edible oils, which are available cheaply, are attractive starting materials for biodiesel [4-5]. The main advantages of this fuel are that its properties and performance are similar to conventional diesel fuels [9-10]. Diesel fuel is very important for countries economy as it has a wide range of usage.

Direct use of vegetable oils or animal fats as fuel can cause numerous engine problems like poor fuel atomization, incomplete combustion, engine fouling and lubrication oil contamination, which is due to higher viscosity. Hence the viscosity of vegetable oils can be reduced by several methods which include blending of oils, micro emulsification, cracking / pyrolysis and transesterification [11]. Among this transesterification is widely used for industrial biodiesel production.

Blending Biodiesel is mixing conventional petroleum diesel with biodiesel to give a biodiesel blend which can be added in any proportion to the petro-diesel [6]. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems.

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The beauty of biodiesel is its potential for reducing greenhouse gases emission and efficient performance in existing diesel engine. 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 [17].
This paper discusses about the basic ways of mixing biodiesel with petroleum diesel, some of the biodiesel blends, emissions of biodiesel and its limitations.

II. MIXING OF BIODIESEL BLENDS

Blending biodiesel with petroleum diesel may be accomplished by [32]:

1. Mixing in tanks at manufacturing point prior to delivery to tanker truck
2. Splash mixing in the tanker truck (adding specific percentages of biodiesel and petroleum diesel)
3. In-line mixing, two components arrive at tanker truck simultaneously.
4. Metered pump mixing petroleum diesel and biodiesel meters are set to X total volume, transfer pump pulls from two points and mix is complete on leaving pump.

SPLASH MIXING METHOD

The most common and least accurate method of blending used for biodiesel is splash blending [38]. Splash blending is done when a truck is already having diesel pumped with biodiesel. The temperature of biodiesel should be 18 to 20 degree Celsius when diesel is colder than 8 degree Celsius [32].

IN LINE MIXING METHOD

Inline blending is done with two storage tanks containing biodiesel components and refinery-produced diesel or diesel components passing through a pipe and hose, mixed in a particular ratio and collected in a third, final product tank [32]. This method allows large volume blends in one go. To avoid the risk of shock crystallization, it is better to have biodiesel temperature 6 degrees Celsius above cloud point. Keeping biodiesel in a diesel tank for a long time is not advisable [32]. Although this method offers better blend consistency for biodiesel than splash blending, density and viscosity changes in the biodiesel require adjustments to the meters for an accurate blend [38].

INJECTION MIXING

Injection mixing is the blending of fuels in tanks at a manufacturing point prior to delivery to the tanker truck. In this method, valve controls ensure that a particular quantity of biodiesel components is injected along with the diesel product in a particular ratio [32].

III. BIODIESEL BLENDS

Blends of biodiesel and conventional hydrocarbon-based diesel are produced by mixing biodiesel and petroleum diesel in suitable proportions under appropriate conditions. Much of the world uses a system known as the "B" [6] factor to state the amount of biodiesel in any fuel mix:

- 100% biodiesel is referred to as B100, while
- 20% biodiesel, 80% petrodiesel is labeled B20
- 5% biodiesel, 95% petrodiesel is labeled B5
- 2% biodiesel, 98% petrodiesel is labeled B2

The most common biodiesel blends in use are:

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B100:

B100 is 100% biodiesel. It has a solvent effect and it can clean a vehicle's fuel system and release deposits accumulated from previous petroleum diesel use. The release of these deposits may initially clog filters and require filter replacement [6].
It may require special handling and equipment modifications. To avoid engine operational problems, B100 must meet the requirements of ASTM D6751 [8], Standard Specification for Biodiesel Fuel (B100). B100 use could also increase nitrogen oxides emissions, although it greatly reduces other toxic emissions. B100 is less common than B5 or B20 due to a lack of regulatory incentives [6].

B20:

B20 (20% biodiesel, 80% petroleum diesel) is the most common biodiesel blend [14]. B20 is popular because it represents a good balance of cost, emissions, cold-weather performance, materials compatibility, and ability to act as a solvent. Using B20 provides substantial benefits and avoids many of the cold-weather performance and material compatibility concerns associated with B100 [20]. Biodiesel blend B20 must meet prescribed quality standards—ASTM D7467 [8]. Biodiesel contains about 8% less energy per gallon than petroleum diesel. For B20, this could mean a 1% to 2% difference, but most B20 users report no noticeable difference in performance or fuel economy. Greenhouse gas and air-quality benefits of biodiesel are roughly commensurate with the blend. B20 use provides about 20% of the benefit of B100 use [14].

B5:

A B5 blend is 5% biodiesel and 95% petroleum based diesel. It is one of the most common blends associated with biodiesel because of the use of a B5 blend in state or municipal mandates. Most major engine manufactures have approved of the use of a B5 blend in their engines [21]. The American Standard for Testing and Materials (ASTM) which sets the international standards for diesel fuel has revised its statements so that a B5 blend is treated the same as conventional diesel ASTM D975-08a [8], Specification for Diesel Fuel Oils, revised to allow for up to 5 percent biodiesel content. This allows B5 blends to be treated the same as conventional diesel for testing purposes.

B2:

B2 is a blend of 2% biodiesel, 98% petrodiesel. It is one of the most common blends associated with biodiesel. It is used in Fleets, Tractor Trailers, off road heavy equipment, on road light duty fleets [23].

IV. EMISSION CHARACTERISTICS OF BIODIESEL

Biodiesel used as blends in different portions to petroleum diesel showed significant improvement in terms of GHG emission. It was observed that on combustion of biodiesel – petroleum diesel blends, the level of carbon monoxide (CO), carbon di-oxide (CO2), smoke, particulate matter (PM) were reduced significantly; whereas the amount of oxides of Nitrogen (NOX) was increased [16]. Since biodiesel is oxygenated, engines have more complete combustion than with ordinary diesel.

EMISSION CHARACTERISTICS OF BIODIESEL BLENDS:

PARTICULATE MATTER (PM)

Particulate matter also known as particle pollution or PM is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals,

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metals, and soil or dust particles [28]. PM emissions from biodiesel are 30-47% lower than overall PM emissions from diesel [37, 40]. Breathing particulate has been shown to be a human health hazard [37].

HYDROCARBONS (HC)

Breathing particulate has been shown to be a human health hazard [41]. The exhaust emissions of total hydrocarbons (a contributing factor in the localized formation of smog and ozone) are on average 20 -67 percent lower for biodiesel than diesel fuel [28, 37].

NITROGEN OXIDES (NOX)

Mono-nitrogen oxides NO and NO2 nitric oxide and nitrogen dioxide are termed as NOx. They are produced from the reaction of nitrogen and oxygen gases in the air during combustion at high temperatures [28]. The oxides of nitrogen (NOx) are precarious pollutant emissions, which are produced, when the fuel is burnt at high temperature causing dissociation of N2, which ultimately leads to the formation of nitric acid. The NOx is also responsible for weakening the ozone layer [34]. NOx emission is from biodiesel increases or decreases depending on the engine family and testing procedures [37]. NOx emission is from biodiesel increased by 10-13 % [37, 41]. NOx increases directly with the degree of blending and as NOx emission increases with increased temperature [39].

SMOG FORMATION

The overall ozone (smog) forming potential of biodiesel is less than diesel fuel. The ozone forming potential of hydrocarbon emission is nearly 50% less than that measured for diesel fuel [37, 42].

SULPHUR EMISSIONS

The exhaust emission of sulphur oxides and sulphates (major components of acid rain) form biodiesel are essentially eliminated compared to sulphur oxides and sulphates from diesel [42]. Sulfates are major contributors to acid rain. These emissions are practically eliminated when using biodiesel [40-41].

CARBON MONOXIDES

Carbon monoxide (CO) is an intermediate product of combustion, formed in the earlier stages of the oxidation process before full conversion in to CO2 [36]. It is emitted in the exhaust stream when its progression to CO2 is not complete due to cooling of fuel flame temperature, or when the engine operation is too fuel rich [28]. The exhausts emissions of carbon monoxide from biodiesel are 48 - 50% lower than from the petroleum diesel [37, 40].

TABLE 1: Average emissions of biodiesel blends for a heavy duty highway engine [25, 28, 35-37]:

Emission Type	B100	B20
Total Unburnt Hydrocarbons	-67 to -20%	-20 to -2.2%
Carbon Monoxide	-34.50 to 48%	-12 to -6.9%
Particulate Matter	-47% to -32.41%	-12 to -6.4%
Oxides of Nitrogen (NOx)	10 to 13.35%	-2 to +2%

-ve sign indicates % decrease in emissions of biodiesel blends compared to petro diesel

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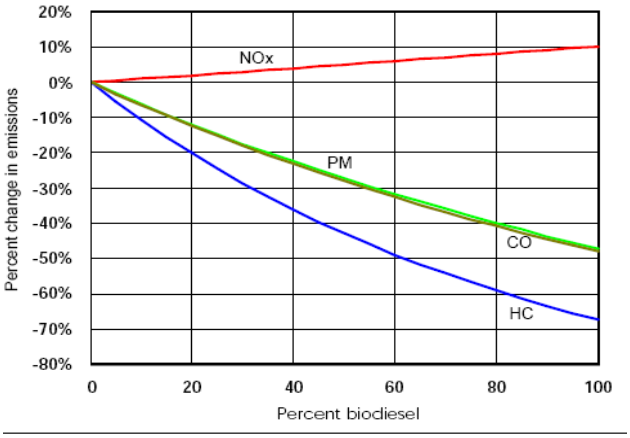

Fig.1 Emissions of biodiesel for a heavy duty highway engine for different blends [13, 35-36]

V. LIMITATIONS

Biodiesel is currently about one and a half times more expensive than petroleum diesel fuel [31]. Biodiesel blends are sensitive to cold weather and may require special anti-freezing precautions. [26] Long-term storage of biodiesel can be a concern because it may oxidize, although additives can ensure stability.[26] "Biodiesel acts like a detergent additive, loosening and dissolving sediments like a detergent additive, loosening and dissolving sediments in storage tanks and also causing rubber and other components to fail; these concerns are typically minimal at low-level blends of biodiesel, and at higher blend levels problems can be avoided with some attention to the materials used in engine fuel injectors and the overall fuel handling system" [26].

VI. CONCLUSION

Biodiesel mixing with diesel improves most of the fuel properties and can be used as an alternative fuel for diesel engines. They have lower emissions and high flash point (usually >300F), hence they are safer [27]. They are biodegradable and essentially non-toxic. Mass emissions of carbon monoxide and particulates found lower with Biodiesel blends, but NOx increased [36]. Other advantages of biodiesel include that its physical and chemical properties are very similar to petroleum based diesel fuel in terms of operation. Therefore, it can be used in diesel engines without expensive alterations to engine or fuel system. It is also biodegradable and free from sulphur and aromatics, making it safer to handle and transport. Biodiesel runs in any conventional, unmodified diesel engine. Addition of even 2% biodiesel helps in significant improvement of lubricity of diesel [22].
The best advantage is the fact that it is a renewable fuel source, while petroleum is limited [18]. This alone will be the reason for its ever increasing popularity.

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