COMPARATIVE ANALYSIS OF BIODIESEL AND PETROLEUM DIESEL

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Abstract
The concerns on climate change, the high energy prices and the dwindling oil reserves and supplies have necessitated a strong interest in the research for alternative fuel sources. Biodiesel is an alternative renewable fuel that has gained massive attention in recent years.Studies on the physical properties of biodiesel have shown that it is completely miscible with petroleum diesel. Since the combustion of biodiesel emits particulate matter and gases which is lower than petrodiesel, combustion of biodiesel and biodiesel blends have shown a significant reduction in particulate matter and exhaust emissions.In this review paper, the use of pure biodiesel or biodiesel blends in terms of performance and exhaust emissions has been studied in comparison to petroleum diesel.

Keywords: biodiesel, transesterification, performance, exhaust emissions, petrodiesel.

1.0 Introduction

As the population increases daily, the demand for energy to meet different lifestyle requirements increase as well. Consequently, the main concern has been on the use of various energy sources. Non-renewables such as fossil fuels like coal, wood, oil, and gas, are likely to be exhausted in the near future since they are nonrenewable as the name implies. These sources of energy cannot be renewed or reused. Alternative fuels from domestic sources are emerging as a solution to the declining reserves of fossil fuels, and the environmental unfriendliness resulting from the combustion of fossil fuels. The fuel that is consumed the most inEurope is biodiesel, a renewable mono-alkyl ester that is produced from vegetable oils, by a transesterification reaction. The use of biodiesel in Europe from 2007 to 2010 represented a share of more than 80% of the transportation biofuel consumption, and 30.26% of the total road transportation fuels consumption in 2010. (Serrano, Carreira, Carama, and Gameiro,2012). When fossil fuels are burned, a lot of carbon dioxide is released. Carbon dioxide is a gas that absorbs heat and contributes towards the greenhouse effect. Another gas released when fossil fuel is burned is sulfur dioxide which combines with water in the atmosphere to form sulfuric acid. This leads to acid rain which alters the

normal pH of soil that supports plant growth.What makes the world today consider the production and use of biofuels on a wide scale is the high level of atmospheric pollution caused by the intense use of fossil fuels leading to the greenhouse effect.It is against this backdrop that fuels namely; biodiesel and petroleum diesel are comparatively analyzed in this review paper.

1.1What is biodiesel?

Biodiesel is an animal or vegetable oil based diesel fuel that burns without the emission of much soot, carbon IV oxide and particulate matter. (Oliveira and Da Silva, 2013). It consists of long chain mono-alkyl esters and is produced by transesterifying vegetable oil or animal fat. In this process, the animal or vegetable oil is converted into biodiesel when one mole of triglyceride reacts with three (3) moles of alcohol to produce a mole of glycerol and three moles of mono-alkyl esters. Biodiesel like petro-diesel is made of hydrocarbon chains that do not contain sulfur, or aromatics compounds in its composition. It is an alternative fuel that is obtained from renewable resources that burns in diesel engines with less environmental pollutants.

1.2 ADVANTAGES OF BIODIESEL

Biodiesel is a fuel that has gained a lot of public attention because it is environmentally friendly and renewable and is being appreciated all over the world. Among the many advantages of using biodiesel, some are listed as follows: the use of biodiesel is not dangerous to the environment. Petrodiesel-powered vehicles produce a considerable amount of emissions, and unfortunately the smokethese vehicles emit is hazardous to the environment.Biodiesel is agriculture oriented, non-toxic, biodegradable and a renewable fuel. It has a high cetane number (a measurement of the combustion quality of diesel fuel during compression ignition), low sulfur, low volatility and presence of oxygen atoms in the fuel molecule.Another of the advantages of biodiesel fuel is that it can also be blended with other energy resources and oil.Biodiesel development will generate employment opportunity for developing countries, where the level of unemployment is relatively high. Biodiesel will also encourage the development of the agricultural sector. (Aregbe,2010).

1.3 DISADVANTAGES OF BIODIESELFUELS

Although biodiesel has gained much scientific attention in recent years, it is not without some few disadvantages. One of the problems encountered when using biodiesel is the increase in nitrogen oxides emissions which can result in the formation of smog and acid rain. Similarly, biodiesel when compared to petro-diesel have a lower energy output.In order to produce the same amount of energy, more biodieselis required than petro-diesel. Also, the use of valuable cropland to grow biodiesel crops could result to a rise in cost of food and furthermore leads to food scarcity (Aregbe, 2010).

1.4 What is petrodiesel?

Petroleum diesel, also called petro-diesel, or fossil diesel is produced when crude oil undergoes fractional distillation between the temperatures of 200^0C and 350^0C at atmospheric pressure, to produce a mixture of carbon chains that contains between 8 and 21 carbon atoms per molecule. Petroleum diesel is a fuel that is used to operate diesel engine-internal combustion engine. Most commonly, it refers to a specific liquid fuel obtained by the fractional distillation of petroleum, often called petro-diesel (Nikitchenko, n.d).

2.0 Comparisons of Biodiesel and Petro-diesel

2.1 Performance Comparative Analysis:

The performance and emission features of compression ignition engines depends on the inner nozzle flow and spray performance. Inner nozzle flow and spray performance in an engine, controls the air fuel mixing, which is necessary for the process of combustion. Because of differences inthe physical properties of biodiesel and petro-diesel,the inner nozzle flow and spray structure are expected to be significantly altered and, consequently the performance and emission features of the diesel engine.(Som, Longman, Ramirez and Aggarwal, 2010). Som *et al* (2010) in their research paper showed that because of lower vapor pressure of biodiesel, it was observed to cavitate less than petro-diesel. A reduction in injection velocity and loss of flow efficiency was also observed because biodiesel viscosity ishigher.

In a review paper by Fallahipanah, Ghazavi, Hashemi, and Shahmirzaei(2011), the performance of biodiesel in an engine which completes a specific cycle was investigated.The paperanalyzed biodiesel fuel and its compounds using thermodynamics laws as well as finite time thermodynamics. Their results showed that when biodiesel is applied as a fuel in the engine, similar results was obtainedand in some cases even better results wasobtained over petro-diesel fuel.From the cycle work shown in figure 1, higher energy output can be achieved at higher compression ratios.

Cumali, Selman, Rasim, and Huseyin(2011),experimented on a diesel engine using biodiesel fuel produced from sunflower oil with petro-diesel. They found that using biodiesel in comparison to using petro-dieselincreased the brake specific consumption but a decrease in pollutants such as particulate matter and carbon monoxide.

The poor lubricity of petro-diesel fuel has led to the failure of engine parts such as fuel injectors and pumps, because these parts are lubricated by the fuel itself.It was also reported that neat biodiesel possesses inherently greater lubricity than petro-diesel, especially low sulfur petro-diesel, and that adding biodiesel at low blend levels (1%-2%) to low-sulfur petro-diesel restores lubricity to the latter. (Goodrum and Geller 2005).

In a research paper by Knothe and Steidley (2005), it was reported that biodiesel has a better lubricity than petro-diesel hydrocarbons, because of the polarity that is introduced with the presence of oxygen atoms which is lacking in petro-diesel. Lubricity it was reported improves with the chain length and the presence of double bonds. One major technical advantages of biodiesel over petro-diesel is lubricity (Knothe*et al,* 2005).

Brake thermal efficiency (BTE) is defined as the ratio between power output and energy introduced through fuel injection (Christopher, Hillary, and Najeem, 2011). In a research conducted by Reddy, Shiva, and Apparao.(2010), on comparing the brake thermal efficiency of diesel fuel and cotton seed methyl ester (biodiesel) blends; it was found that the brake thermal efficiency is always found to be lower with biodiesel blends as compared with petro-diesel.The result from the experiment conducted by Christopher *et al*(2010) also showed that blending biodiesel with petro-diesel decreases the brake thermal efficiency (BTE) and on the other hand increases the brake specific fuel consumption (BSFC) which is defined as the rate of fuel consumption divided by the power produced. The BSFC of biodiesel and biodiesel blends they found to be higher in comparison to that ofpetro-diesel. This can be as a result of the lower viscosity, density and higher heating value of the petro-diesel.

The bar chat in Figure 2 of BTE % against fuel blends reveals that blends of biodiesel and petrodiesel fuels decrease the brake thermal efficiency (BTE). The BTE of biodiesel and its blend is lower than compared to petro-diesel.

From the information in Figure 3, it can be concluded that the brake specific fuel consumption (BSFC) increased with the increase in the ratio of biodiesel in the blends.

In another work, indirect injection diesel engine was studied with petrodiesel and 100% biodiesel at various fuel injection pressures by Kumar, Ramesh, and Sahoo.(2012). It was observed that at 100% load, brake thermal efficiency of biodiesel increases as the fuel injection pressure is increased keeping advance angle of fuel injection constant, whereas for petro-diesel, the brake thermal efficiency decreases under the same conditions.

2.2 Emission Comparative Analysis:

The environmental impact of biodiesel depends on several factors which are; the raw materials from which the biodiesel was produced, different production processes and the final use can determine the environmental balance of biodiesel introduction (Nanaki and Koroneos. 2012). Replacing biodiesel with petro-diesel fuel can produce environmental advantages as well as disadvantages.Prominent among the advantages that biodiesel has over petro-diesel isthat biodiesel has the potential of reducing most exhaust emissions that have regulations, excluding nitrogen oxides (NOx). Knothe, Sharp, and Ryan. (2006), in their work used a heavy-duty 2003 six-cylinder 14 L diesel engine with exhaust gas recirculation to analyze, neat methyl laurate, neat methyl palmitate, and technical grade methyl oleate, forexhaust emissions.The three fatty acid methyl esters, was compared with pure dodecane and hexadecane, and pure biodiesel sample as well as petro-diesel with low sulfur content. All fuels were analyzed and tested for exhaust emissions.Emissions of particulate matter were found to decrease to about 77% and 73% for biodiesel and methyl oleate respectively.Similarly, the reduction in particulate matter emissions for methyl laurate and methyl palmitate was even greater,83% and 82% respectively in comparison to petro-diesel. An increase of about 12% NOx emissions was observed for biodiesel, while an increase of about 6% was observed for methyl oleate, but methyl palmitate and methyl laurate particulate matter emission was reduced by about 4-5% relative to those of the base fuel (Knothe*et al*, 2006). Overall, biodiesel fuel and the fatty compoundsconsiderably reduced particulate matter

emissions by 75%-83% when compared to the petro-diesel base fuel, whereas the two hydrocarbonscomponents found in petro-diesel; dodecane and hexadecanereduced particulate matter emissionby only 45-50%.

Similarly, in a research by Rubianto, Yuwono, and Soemarno. (2013), they found that biodiesel has a contribution to reduce particulate emission from combustion on a boiler burner with reduction of 29.796%. This percentage of reduction is significant to decrease air pollution, creating a better and healthier environment.

Table 1 showed that blending biodiesel with petro-diesel at various ratios, leads to a decrease in the amount of particulate matter being emitted as the amount of biodiesel is increased in the blend from B0 to B10. From B15 to B30 there is a significant decrease in the amount of particulate matter emitted. The graph in figure 4 shows the emission of particulate matter at different percentages of biodiesel amount in the blends.

In a review paper by Rashid (2011), he reported that in an assessment of the environmental hazards caused by the use of fossil fuels, biodiesel is being considered to be the best fuel for diesel engines since burning biodiesel and its blends has the lowest Green House Emissions on a life cycle basis. The emission of carbon monoxide gas is reduced by using biodiesel as a fuel. Carbon monoxide gas is a toxic byproduct of all hydrocarbon combustion. The use of biodiesel in blends, or its pure form reduces emissions such as; particulate matter, visible smoke,odor, and polyaromatic hydrocarbon emissions. His review paper also showed that particulate soot emissions which have adverse health effect in terms of respiratory impairment and related illness is significantly reduced with the use of biodiesel or its blends. Furthermore, biodiesel does not contain undesirable element like sulphur as compared to petrodiesel, which may have Sulphur content. The review showed that biodiesel is a fuel that is clean and environment friendly, which can supplement or replace petro-diesel as a fuel in the future (Rashid2011).

3.0 Conclusion

Biodiesel is a renewable alternative fuel that can be used in a diesel engine either pure or in blends with petroleum diesel. It has the potential of replacing petroleum diesel in the future, or being used in blends with petroleum diesel to improve performance and reduce toxic exhaust emissions. In terms of environmental assessment and renewability, biodiesel has a contribution in reducing particulate matter emission, reduced emission of greenhouse gases, and decrease in air pollution. Biodiesel when applied as a fuel in a diesel engine works like petro-diesel or in some cases even gives better results compared to petro-diesel fuel.

We have reviewed past research works comparing performance and exhaust emission characteristics of biodiesel and petro-diesel from different sources. Because of the growing concern for a clean and healthy environment, most modern research has been centered on reducing the toxic exhaust emissions generated from burning petroleum and improving the performance of petro-diesel through blending with biodiesel.

LIST OF FIGURES AND TABLE

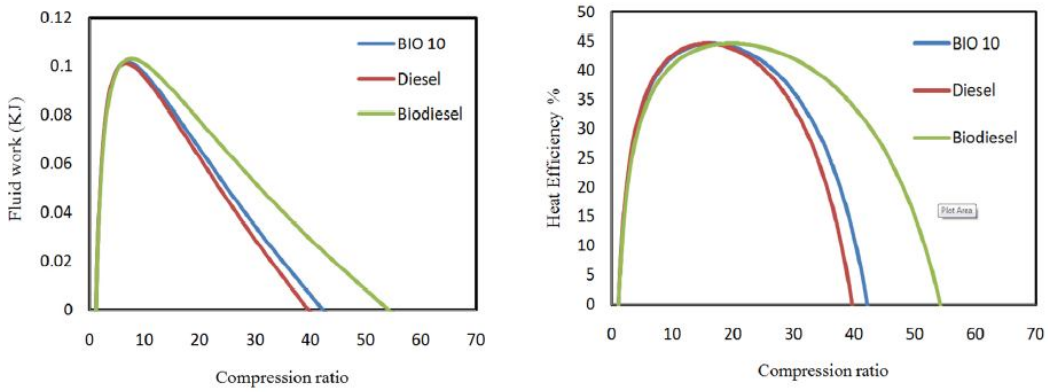

Fig 1- Fluid work and Heat efficiency versus Compression ratio for diesel, biodiesel, and BI0 10 (Fallahipanah et al 2011).

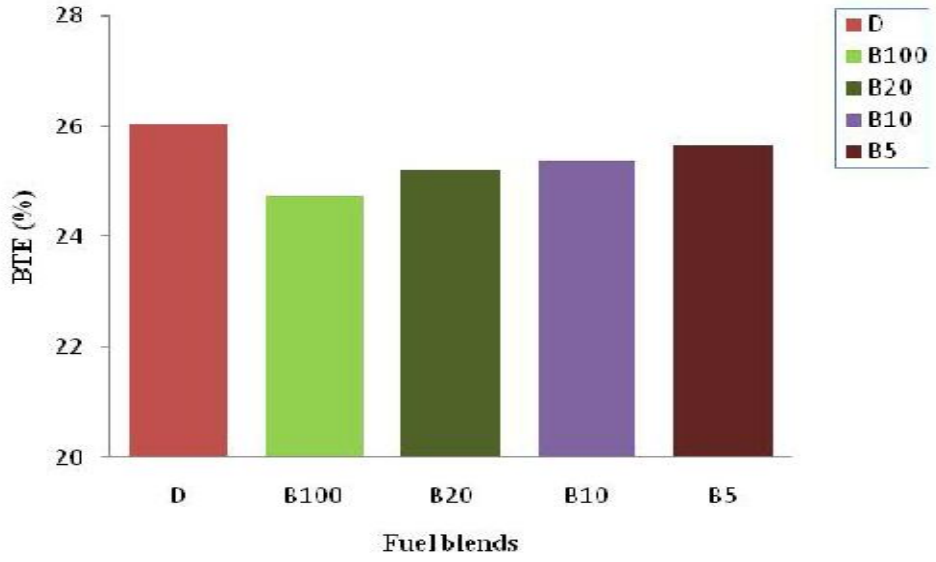

Fig. 2: Comparison of BTE for diesel and biodiesel- diesel blends at full load (Christopher et al 2010).

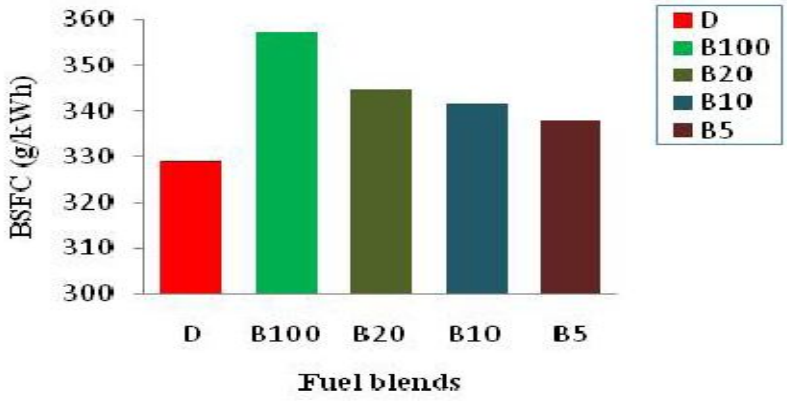

Fig. 3: Comparison of BSFC for diesel and biodiesel-diesel blends at full load (Christopher et al 2011).

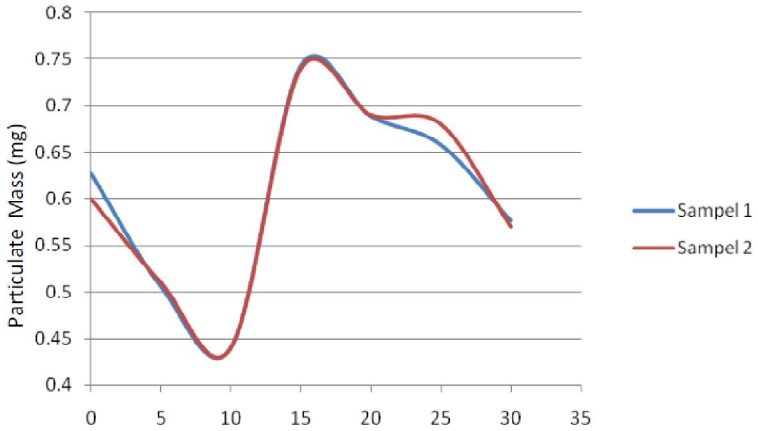

Fig 4- Graph of Particulate Mass versus Biodiesel percentage (Rubianto et al 2013).

Table 1 showing the amount of particulate matter emitted for petrodiesel (B0) and biodiesel blends (Rubianto et al 2013).

Fuel Mixture	Particulate Mass, Sample 1 (gr)	Particulate Mass, Sample 2 (gr)
B0	0.6276	0.6002
B5	0.5061	0.5101
B10	0.4406	0.4402
B15	0.7433	0.7404
B20	0.6889	0.6903
B25	0.6585	0.6801
B30	0.5762	0.5704

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