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Emission Characteristics, Fuel Efficiency and Engine Power of Neem Oil Biodiesel Determined From IC Engine

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Aims: To evaluate the emission characteristics and engine performance of neem oil biodiesel using a single cylinder one-stroke 165 jet diesel engine.

Study Design: Automotive gas oil (AGO) was blended with neem oil biodiesel (NOB) in the following percentages (100:0; 90:10; 80:20; 70:30; 60:40; 50:50; 40:60; 30:70; 20:80; 10:90 and 0:100) respectively

Place and Duration of Study: The experiment was carried out in the Department of Chemical engineering, Obafemi Awolowo university, Ile Ife and Department of Mechanical engineering, Obafemi Awolowo university, Ile Ife, Nigeria, between January 2011 and October, 2012.

Methodology: The AGO was blended with NOB as shown in the design of study. The blends were subjected to combustion in the single cylinder one-stroke jet diesel engine coupled with EGA4 palm top flue gas analyzer which was used in order to determine the effect of varying speed (750rpm and 900rpm) on the exhaust gases (CO and NO). Also, the engine power and specific fuel consumption were calculated in order to determine the efficiency of neem oil biodiesel in combustion engine. The combustion and the analyses were carried out, first by using a 100% AGO, then 100% NOB followed by the other blends.

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Results: The result showed that there were reduction in CO and NO emission while using neem oil biodiesel. The result also showed that neem biodiesel blends had engine power and specific fuel capacity similar to AGO.
Conclusion: Neem oil biodiesel can be used with or without blends with AGO in diesel jet engines with lower emission characteristics and similar engine performance with that of AGO.

Keywords: Emmision characteristics; combustion engine; neem oil biodiesel; CO; NO.

1. INTRODUCTION

In recent years, Biodiesel has become more attractive as an alternative fuel for diesel engines because of its environmental benefits and the fact that it is made from renewable resources [1]. This had led to the conclusion that vegetable oils hold promise as alternative fuels for diesel engines [2,3]. A condition for the short and half-term success of biofuels is that they can be used with current engines without having to make any expensive modifications [4]. In addition, various blends had been considered in order to determine the efficiencies of the various blends compared with the normal diesel [5]. Though there are some positive environmental impacts on the use of biodiesels in diesel engines, there is a need to analyze their exhaust emissions for the benefit of human health and other environmental concerns. Test bench had been used to carry out the emission characteristics of biodiesel [4]. It has been shown that making and burning of biodiesel inside the diesel engines as fuel contributes to atmospheric carbon dioxide, sulphur dioxide, NOx, smoke and particulate matter emissions to a smaller extent than burning the conventional diesel [6]. Density, Calorific Value and Cetane Number are significant factors that influence the formation of exhaust emissions.

It had been discovered that biodiesels and their blends give lower emissions compared to diesel. Many studies have reported that exhaust from biodiesel fuel gives higher oxides of nitrogen or lower, while HC and smoke emissions are significantly lower than that of diesel fuel (Gopinath et al. [7]). Biodiesel having more unsaturated fatty acids emit more oxides of nitrogen and exhibit lower thermal efficiency compared to biodiesel having more saturated acids. Thermal efficiency and NO_X emission of saturated biodiesel is comparatively better than other biodiesel. Investigation has shown that the NO_X concentration in the exhaust emissions increases with increase in biodiesel density, iodine value and percentage of unsaturation. A reduction in CO and NOx emission had been observed in a diesel engine running with olive oil [7,8].

Neem oil had been extracted from neem seed, its physicochemical properties determined and production feasibility and quality evaluation of biodiesel from the neem oil carried out [9,10]. Result of the works showed that the production of neem oil biodiesel (NOB) is viable considering its yield, physicochemical properties and fatty acid profile via gas chromatography analyses. There is therefore need to carry out combustion, performance and emission analyses in order to determine the environmental impact of NOB and its performance in diesel engines. This work studied the emission characteristics and engine performance of blends of neem oil biodiesel (NOB) and automotive gas oil (AGO) in diesel engine.

2. MATERIALS AND METHODS

2.1 Materials

AGO was purchased from Obafemi Awolowo University filling Station, Ile Ife, Nigeria; A single cylinder one-stroke 165F jet diesel engine obtained from Department of Mechanical Engineering, Obafemi Awolowo University, Ile Ife; neem oil biodiesel was obtained from two-steps transesterification of neem oil.

2.2 Methods

The Neem oil biodiesel were blended with the AGO in ratios shown in Table 1. The engine was operated on diesel first and then on Neem oils biodiesel and their blends. The different fuel blends and AGO were subjected to performance and emission tests on the engine. The emissions of NO and CO were recorded. The air gas flue temperature was also recorded. The volume of AGO that remain from individual blend was determined, and the time each blend was run was also determined.

2.2.1 Engine power determination

The Engine power is determined from the time to run each blend as given in Eq. (1)

$$Engine\ power = 3.23KW\ per\ hr \quad (1)$$

2.2.2 Specific fuel consumption determination

The formula used to determine the specific fuel consumption is given in Eq. (2)

$$Specific\ fuel\ consumption = \frac{volume\ of\ fuel\ used}{engine\ power \times time} \quad (2)$$

2.2.3 Mass of oxygen in blends

The mass of oxygen in the blend, *Mo,* is determined using Eq. (3)

$$Mo = 0.34\rho_1 v_1 + 11\rho_2 v_2 \quad (3)$$

Where

V1 = volume of biodiesel in blend
V2 = volume of AGO in blend
ρ1 = density of biodiesel
ρ2 = density of AGO

3. RESULTS AND DISCUSSION

3.1 CO and NO Emissions

CO emission was generally lower in NOB and blends compared to 100 % AGO at the speeds considered (Figs. 1 and 2). Percentage reduction at 750 rpm is from 26% to 59%, while at 900 rpm, it is from 18% to 53%. Previous works also confirmed this result. The reduction is CO emission by NOB (Biodiesel) compared to AGO (fossil diesel) is one of the major reasons researches into the use of biodiesel and biodiesel blends as an alternative to 100 % fossil fuel has been promoted. Reduction in CO which directly contributes to greenhouse effect is a major benefit of biodiesel usage. NOB in this work therefore has a reasonable environmental effect with the reduction in the CO. Comparing CO emission at 750 rpm and 900 rpm (Fig. 3) actually showed no difference in the level of CO emitted. The higher the amount of biodiesel (NOB), the lower the CO emission.

It had been shown that CO and HC emissions increase with increase in unsaturation which may be as a result of lower oxygen concentration in higher unsaturated biodiesel fuels. The oxygen content decreases with increase in unsaturation [7]. Many studies have reported that exhaust from biodiesel fuel gives higher oxides of nitrogen or lower, while HC and smoke emissions are significantly lower than that of diesel fuel [6,8]. Possible explanations are the physical properties and fatty acid composition of biodiesel affecting the spray and the mixture formation with reduced heat losses [7].

Following the same pattern is the NO emission (Figs. 4 and 5). With exception of B40 which had the same NO emission as 100 % AGO at 750rpm, all other blends showed reduction in NO emission (20 – 60%) while at 900 rpm, all biodiesel blend produced lower NO emission (20 – 80%). This is another merit of NOB since most biodiesel showed increased NO compared to 100 % AGO [6]. Increasing the speed reduces the NO emission further (Fig. 6)

Table 1. Blends of neem oil biodiesel/AGO

S/N	Blend	% AGO	% Neem Oil biodiesel
1	AGO	100	0
2	B10	90	10
3	B20	80	20
4	B30	70	30
5	B40	60	40
6	B50	50	50
7	B60	40	60
8	B70	30	70
9	B80	20	80
10	B90	10	90
11	B100	0	100

**AGO: Automotive gas oil*

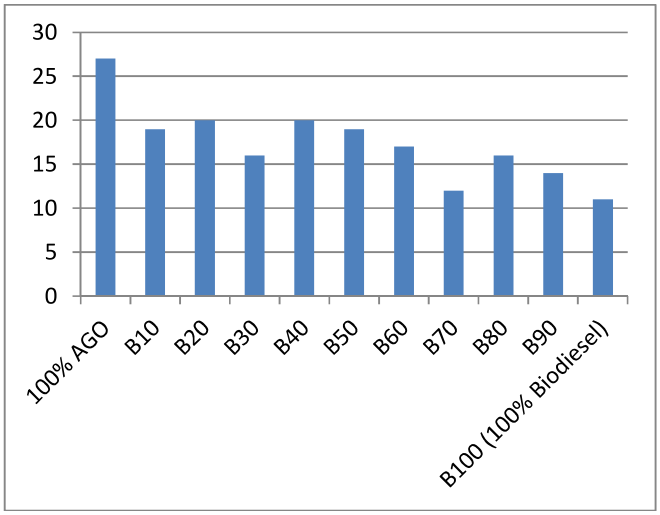

Fig. 1. CO emission at 750 rpm for 100 % AGO, 100 % NOB and Blends

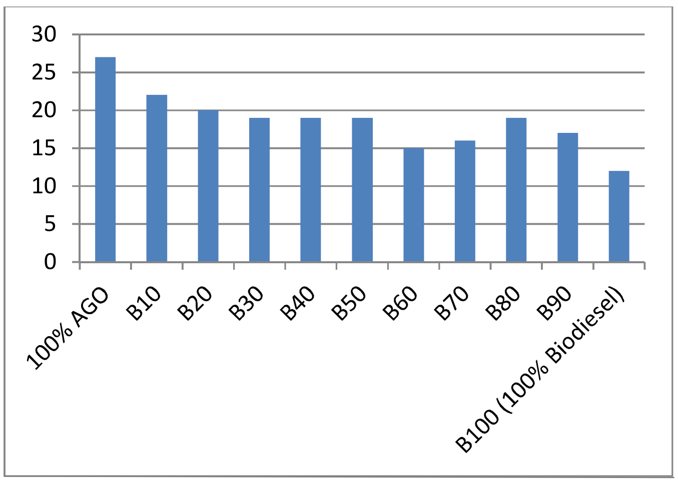

Fig. 2. CO emission at 900 rpm for 100 % AGO, 100 % NOB and Blends

3.2. Engine Power

The result showed that 100 % AGO, B10 and B40 had the best engine power while B50 and B70 had the lowest (Fig. 7). Previous works showed that when an engine uses biodiesel, power is lower [11], which is due to chemical differences between biodiesel and fossil diesel [12]. This loss in power had been shown to be in the range of 1 – 8 % depending on the source. It had been shown that though unsaturated esters have lower energy content on a weight basis, but due to their higher density, they have more energy per unit volume. The slight reduction in power has been found to be as a result of lower calorific value of biodiesel. The calorific value of NOB is 39.89 MJ/Kg as against 42.6 MJ/Kg of No 2 diesel [12]. The use of additives had been shown to optimize the combustion behavior and hence improve engine performance [13].

3.3 Specific Fuel Consumption

The result of the specific fuel capacity as presented in Fig. 8 showed that specific fuel capacity had inverse relationship with engine power. Diesel (100 % AGO) showed different behavior when compared to B40 and B60 although they all had the same engine power behavior (Fig. 7). The implication of this is that though diesel fuel (100 % AGO) and biodiesel blends (B40 and B60) have the same engine power, diesel (100 % AGO) showed better fuel efficiency in having insignificant specific fuel consumption. It had been shown that specific fuel capacity increases with increase in percentage biodiesel. In addition, the lower cetane number and lower calorific value of biodiesel resulted in higher specific fuel consumption [11,14]. The cetane number and calorific value of NOB are 55.31 and 39.89 Mj/Kg [10].

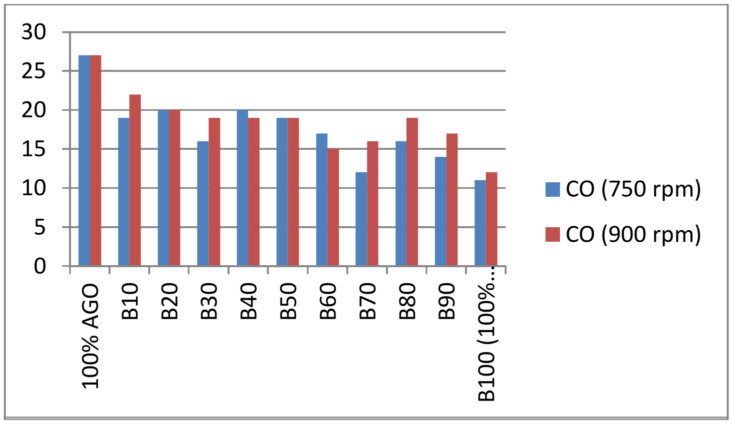

Fig. 3. CO emission at 750 rpm and 900 rpm for 100 % AGO, 100 % NOB and Blends

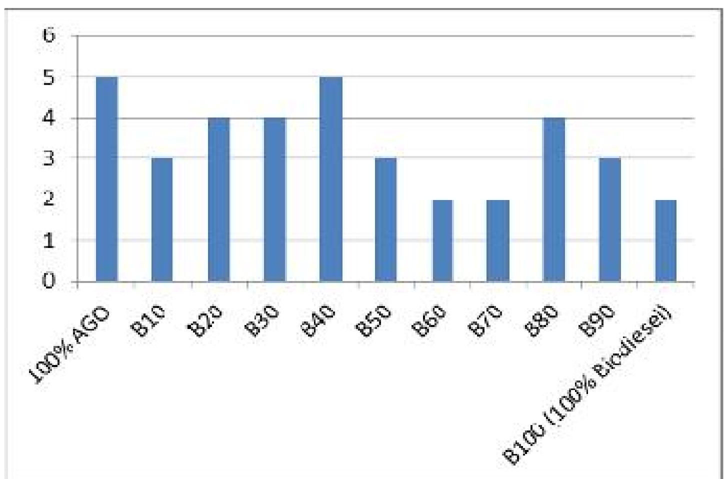

Fig. 4. No emission at 750 rpm for 100 % AGO, 100 % NOB and Blends

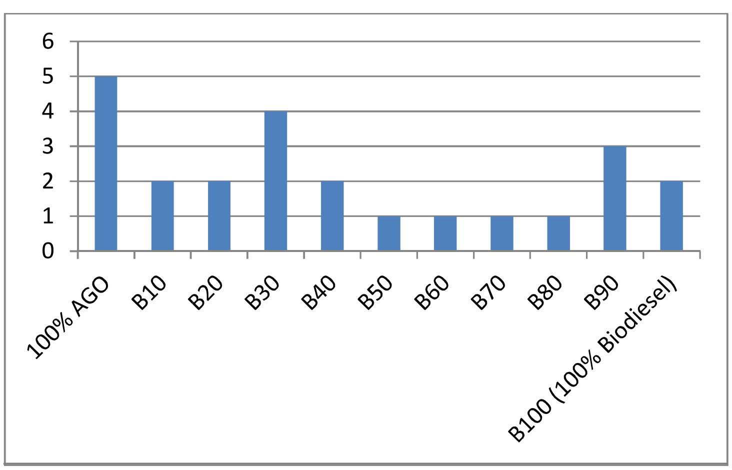

Fig. 5. NO emission at 900 rpm for 100 % AGO, 100 % NOB and Blends

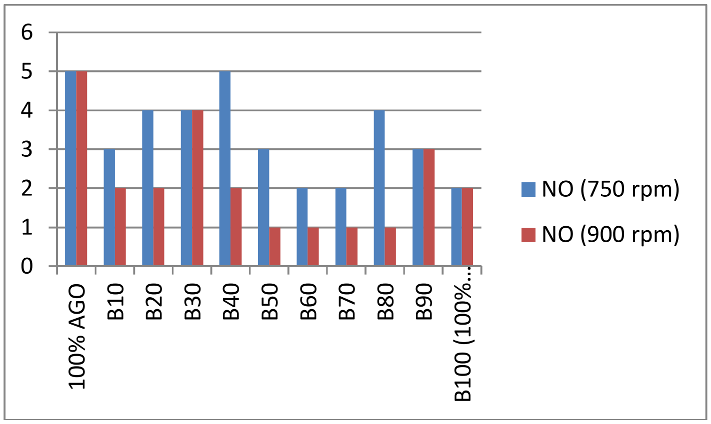

Fig. 6. NO emission at 750 rpm and 900 rpm for 100 % AGO, 100 % NOB and Blends

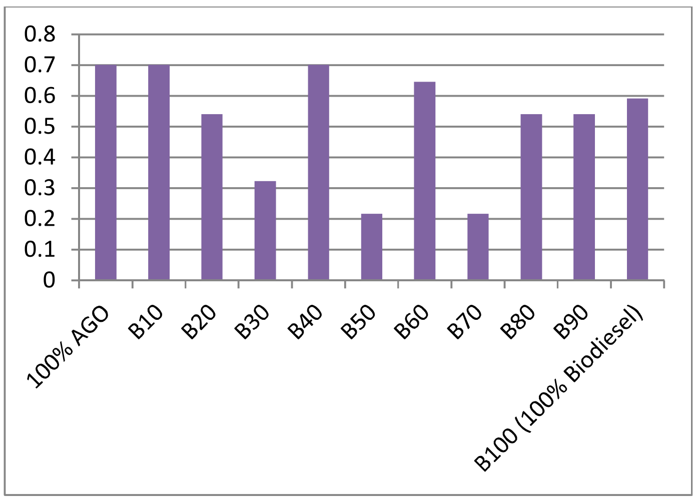

Fig. 7. Engine power of 100 % AGO, 100 % NOB and Blends at 750 rpm and 900 rpm

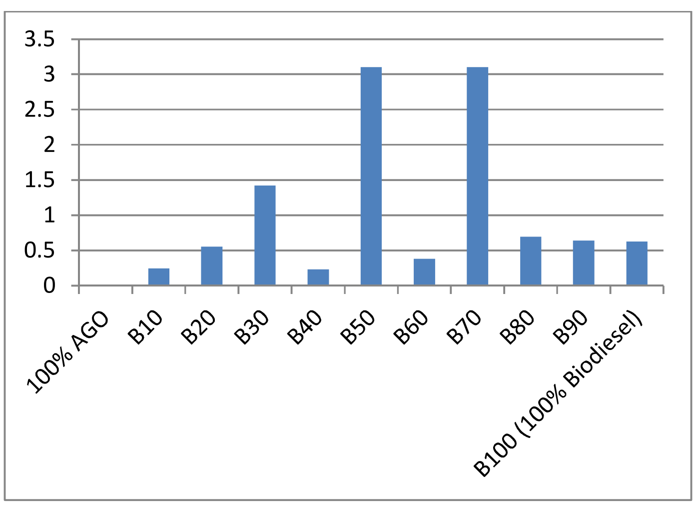

Fig. 8. Specific fuel consumption 100 % AGO, 100 % NOB and Blends at 750 rpm and 900 rpm

4. CONCLUSION

This work has been able to measure the combustion exhaust of neem oil biodiesel, and compare it with automotive gas oil. In addition, the compatibility of neem oil biodiesel in combustion engine was ascertained. Neem oil biodiesel had lower combustion emission in terms of NO and CO and it can be used in combustion engine with or without blends without modification. The power output of neem oil biodiesel was comparative to that of automotive gas oil.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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