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Comparative Property Analysis Of biodiesel Blended With Ago and Petroleum Diesel (Ago).

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ABSTRACT
The study, comparative property analysis of biodiesel blended with AGO and petroleum diesel (AGO) was successfully investigated. Researchers adopted a biodiesel produced from palm kernel oil using direct base –catalyst transestrification. The palm kernel oil was pre-treated by heating to remove water and other impurities which do hinder transestrification. Solution of sodium hydroxide in methanol was used as the base-catalyst. The bioreactor was designed and fabricated by the researchers. Petroleum diesel (AGO) adopted in the study was obtained from Nigerian National Petroleum Corporation (NNPC) mega station in Owerri.20% by volume of biodiesel produced was blended with 80% by volume of Petroleum diesel (AGO). The samples of blended biodiesel (**20% / 80% vol/vol biodiesel / diesel**) produced and the petroleum diesels (AGO) were sent together to the Shell Petroleum Development Company (SPOC) laboratory for property analysis. Results showed that the relative density or specific gravity of AGO or petroleum diesel was found to be 0.8709 with that of 20% blended biodiesel with AGO being 0.8735 at 15℃. These findings indicated that AGO blended with 20% biodiesel has relative density closer to natural petroleum diesel. Therefore, to minimize air pollution arising from petroleum diesel combustion, diesel (AGO) could be blended with biodiesel at rates below 20% to lower the relative density or specific gravity. Also, the kinematic viscosity of petroleum diesel (AGO) was found to be 4.9 centistokes whereas that of AGO blended with 20% biodiesel was 6.02 centistokes at 40℃. These results showed that AGO blended with 20% biodiesel offers higher internal resistance to flow compare to petroleum diesel. In addition, the average heat of combustion of AGO or petroleum diesel was found to be 41,478.30 kJ/kg with that of 20% blended biodiesel with AGO being 42,332.61 kJ/kg**.** These results revealed that blending petroleum diesel (AGO) with biodiesel increases heating value above that of natural diesel, AGO. Thus, blends are good fuels with zero starting problems even in winter period as the study revealed. MATLAB was used to evaluate the variance and standard deviation of heat of combustion of diesel(AGO) and 20% blended biodieseland were found to be 7,558.70kJ/kg and 86.9406respectively.The researchers made the following recommendations:To minimize air pollution arising from petroleum diesel combustion; diesel (AGO) could be blended with biodiesel at rates below 20% to lower the relative density or specific gravity of aromatic compounds, there would be need to redesign fuel injector, pump system and fuel flow lines to accommodate higher internal resistance to flow offered by the alternative fuel, etc.

Keywords ---- Biodiesel, AGO, transestrification, palm kernel oil, bioreactor, heating value, sodium hydroxide, variance, standard deviation.

I. INTRODUCTION

The strong interest on climate change, coupled with high energy prices and the depleting oil reserves and supplies are measures of strong interest in the research for alternative fuel sources. Biodiesel is an alternative renewable fuel that has gained massive attention in recent years. Researches carried out on the physical and chemical properties of biodiesel have revealed that it is completely miscible or can be blended with petroleum diesel. Also, the combustion of biodiesel emits particulate matter and gases which are lower than petro diesel, combustion of biodiesel and

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biodiesel blends have shown a significant reduction in particulate matter and exhaust emissions. (Demshemino, Donnell, Muhammad, Isioma, & Okoro, 2013).

According to Friso (2014) as cited by Musa et al, (2019) stated that biodiesel has been seen as a reliable energy resource due to its renewable nature which can be used as a whole or in blends with petroleum diesel. In addition, the use of whole biodiesel showsenvironmental friendliness, despite the non-feasibility of using it as a whole currently due toeconomic constraints. The need to know property analysis of biodiesel blended with petroleum diesel becomes a thing of paramount.

Goodrum and Geller (2005) opined that petroleum diesel (AGO) has poor lubrication property and this had contributed to the failure of engine parts such as fuel injectors andpumps, as fuel adds in the lubrication of these parts. Furthermore, itwas reported that blended biodiesel possesses greater lubricity compare to petroleum diesel. Adding biodiesel at low blend levels (1%-2%) to petroleum diesel restores lubricity in AGO.

According to reviewed literatures, specific fuel consumption of biodiesel blends was foundto be higher in comparison to that of petroleum diesel. This was attributed to the lower viscosity, density and higher heating value of the petroleum diesel.Hence, the paper aimed at studying comparative property analysis of biodiesel blended with AGO and petroleum diesel (AGO).

II. MATERIALS AND METHODS

Oliveira and Da Silva (2013) as cited in Demshemino et al, (2013) explained that biodiesel is an animal or vegetable oil based diesel fuel that burns without the emission of muchsoot, carbon IV oxide and particulate matter. The biodiesel adopted by the researchers in this study was produced using palm kernel oil and direct base -catalyst transestrification in Federal Polytechnic Nekede, Owerri in Imo State Nigeria. The palm kernel oil was obtained from the wild farm located at Umuorie village, Naze, Owerri North Local Government Area and was pre-treated by heating to remove water and other impurities which do hinder transestrification. Solution of sodium hydroxide in methanol was used as the base-catalyst. The bioreactor was designed and fabricated in the mentioned location.

Petroleum diesel (AGO) adopted in this study was obtained from Nigerian National Petroleum Corporation(NNPC) mega station in Owerri.Petroleum diesel or fossil diesel is produced when crude oil undergoesfractional distillation between the temperatures of 200℃ and 350℃ at atmospheric pressure, toproduce a mixture of carbon chains that contains between 8 and 21 carbon atoms per molecule.

The samples of blended biodiesel (**20% / 80% vol/vol biodiesel / diesel**) produced and the petroleum diesel obtained from Nigerian National Petroleum Corporation (NNPC) mega station in Owerri were sent together to the Shell Petroleum Development Company (SPOC) laboratory for property analysis.

PROPERTIES ANALYZED

The following properties were tested for: relative density or specific gravity, kinematics viscosity, cetane number, flash point, pour point, and heat of combustion. The heat of combustion was determined with a bomb calorimeter at the thermodynamics laboratory, Fedreal Polytechnic, Nekede. The cetane number was determined in the Chemistry Laboratory, Petroleum Training Institute, Effurun.

DESIGN ANALYSIS

The heat conduction equations during combustion process of fuel in a control volume for one, two and three dimensional flows are given below:

$$\frac{\partial^2 T}{\partial x^2}+\frac{Q_G}{K}=\frac{1}{\alpha}\frac{\partial T}{\partial t} \quad \textbf{... (1.0)}$$(Khurmi & Gupta, 2012)

Where k = thermal conductivity of medium and α = thermal diffusivity

Q_G = internal heat generation

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{Q_G}{K}=\frac{1}{\alpha}\frac{\partial T}{\partial t} \quad \textbf{... (2.0)}$$

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}+\frac{Q_G}{K}=\frac{1}{\alpha}\frac{\partial T}{\partial t} \quad \textbf{... (3.0)}$$

The value of higher calorific value of biodiesel can be determined using Dulong's formula as shown below:

$$H.C.V = 33,800C + 144,000\,H_2 + 9,270S \text{ kJ/kg}$$ …..(**4.0**)

(Khurmi & Gupta, 2012)

if fuel contains oxygen, the formula below can be used

$$H.C.V = 33,800C + 144,000\left(H_2 - \frac{O_2}{8}\right) + 9,270S \text{ kJ/kg}$$…….**(5.0)**

where C, H_2 and S, represent mass of carbon, hydrogen and sulphur in 1kg of fuel.

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Net or Lower Calorific Value, this is the one mostly used in actual practice. The heat carried away by flue gases is not recovered and the steam formed during combustion is not condensed. It is shown as below:

$L.C.V = H.C.V - m_s \times 2{,}466$ kJ/kg …..(**6.0**)
where m_s = mass of steam formed = $9H_2$
The general equation for the combustion of a hydrocarbon fuel is

$C_xH_y + (x + \frac{y}{4}O_2) \rightarrow xCO_2 + 2H_2O$……(**7.0**)(Khurmi & Gupta, 2012)

In the above,$(x + \frac{y}{4})$ is the stoichiometric amount of oxygen required to fullyoxidize a hydrocarbon fuel.

Specific gravity is the ratio of the specific weight of the liquid to the specific weight of a standard fluid. It is dimensionless and has no units. It is represented as S.

$$\text{Specific gravity} = \frac{\text{specific weight of liquid}}{\text{specific weight of pure water}}$$

…….(8.0)
Kinematic viscosity is defined as the ratio between the dynamic viscosity and density of fluid.

$$v = \frac{\text{viscosity}}{\text{density}} \quad \text{….. (9.0)}$$

Its unit is m^2/s, the
dynamic viscosity or viscosity is given as:

$\frac{du}{dy}$ = velocity gradient
τ = shear stress

$$\mu = \frac{\tau}{\frac{du}{dy}} \quad \text{….. (10.0)}$$

III. RESULTS AND PRESENTATIONS

Table 1.0: Shows the Physical and Chemical Properties of Fuel Samples.

PARAMETER	NNPC (AGO) OR DIESEL	20% BLEND OF BIODIESEL AND DIESEL
SPECIFIC GRAVITY @ 15℃	0.8709	0.8735
KINEMATIC VISCOSITY@ 40℃ (cst)	4.9	6.02
FLASH POINT ℃	126.7	126.7
POUR POINT ℃	< -26	< -26

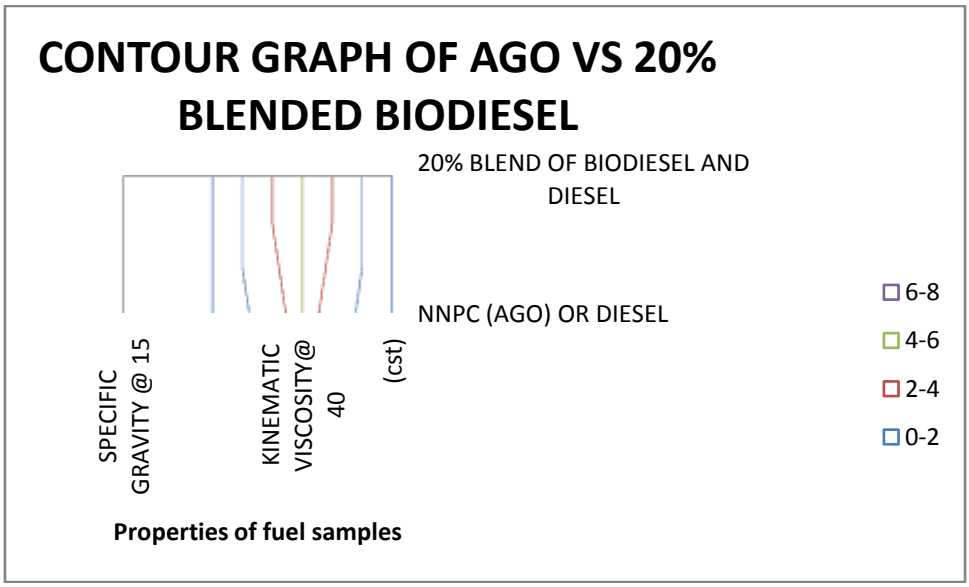

Fig 1.0 Contour Graph of Properties of AGO versus 20% blended Biodiesel

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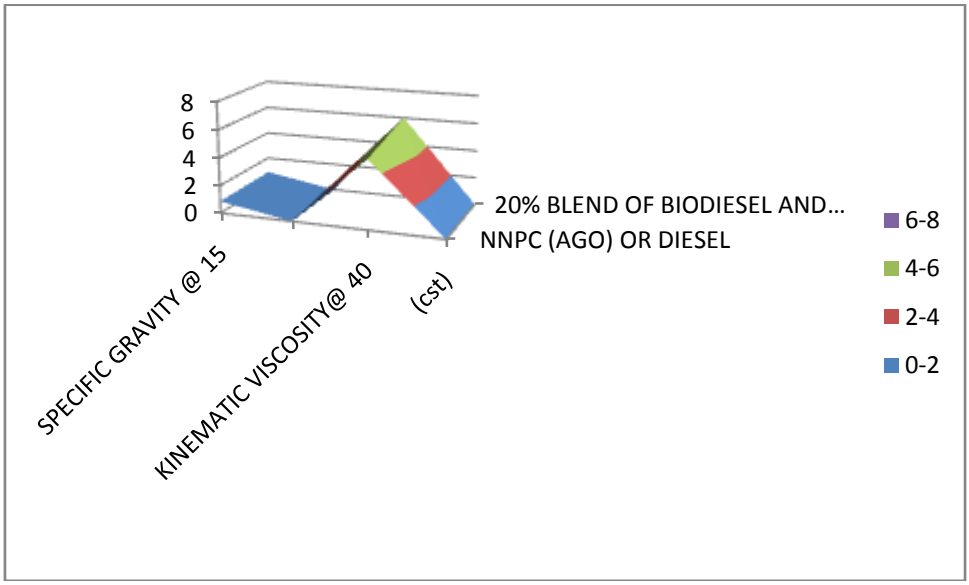

Fig 2.0 Area Graph of Properties of AGO versus 20% blended Biodiesel

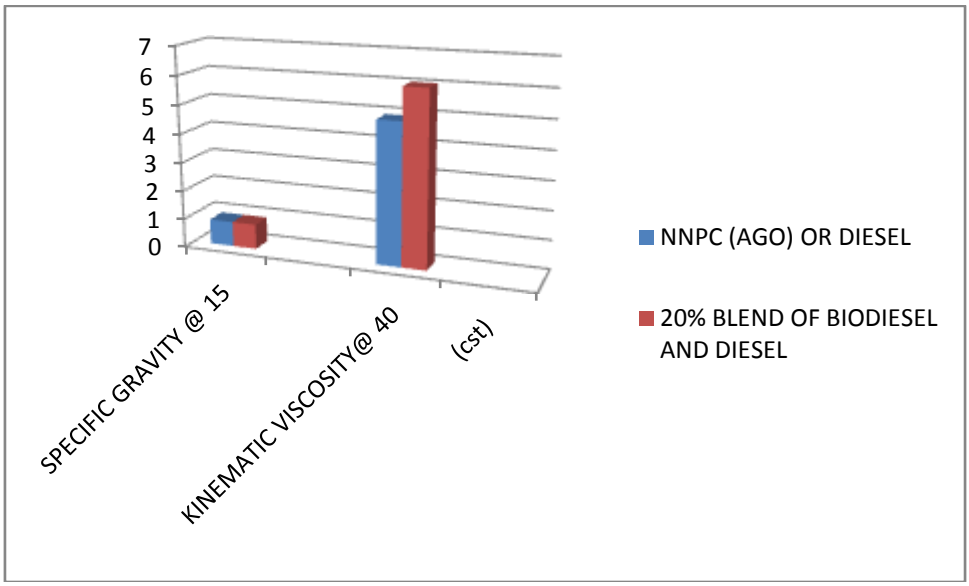

Fig 3.0 Bar Graph of Properties of AGO versus 20% blended Biodiesel

Table 2.0: shows the Heat of Combustion of the Fuel Samples.

FUEL	HEAT OF COMBUSTION (1st sample) kJ/kg	HEAT OF COMBUSTION (2nd sample) kJ/kg	HEAT OF COMBUSTION (Average value) kJ/kg
DIESEL (AGO)	41,391.30	41,565.20	41,478.30
20% BIODIESEL	42,956.52	41,708.70	42,332.61

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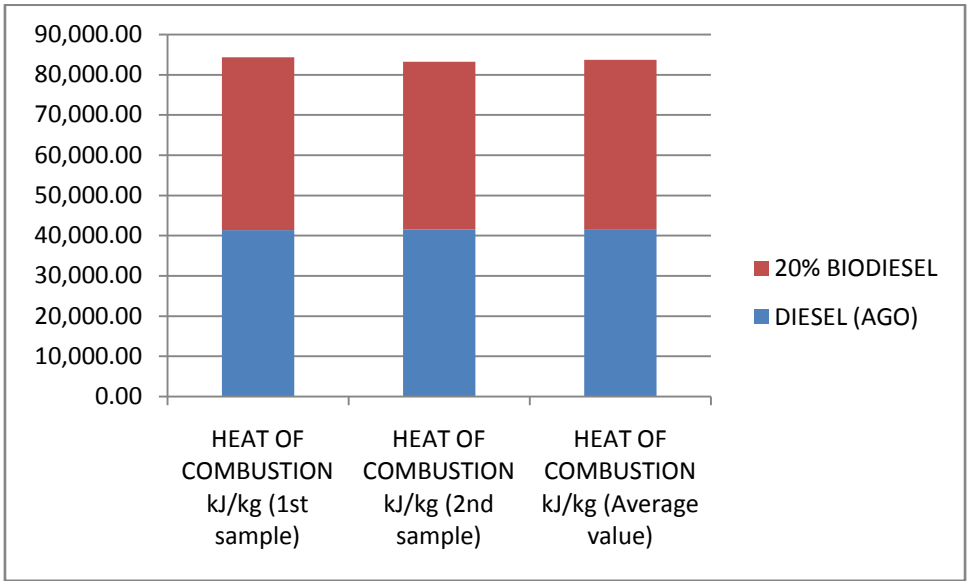

Fig 4.0 Bar Graph of Heat of Combustion of AGO versus 20% blended Biodiesel

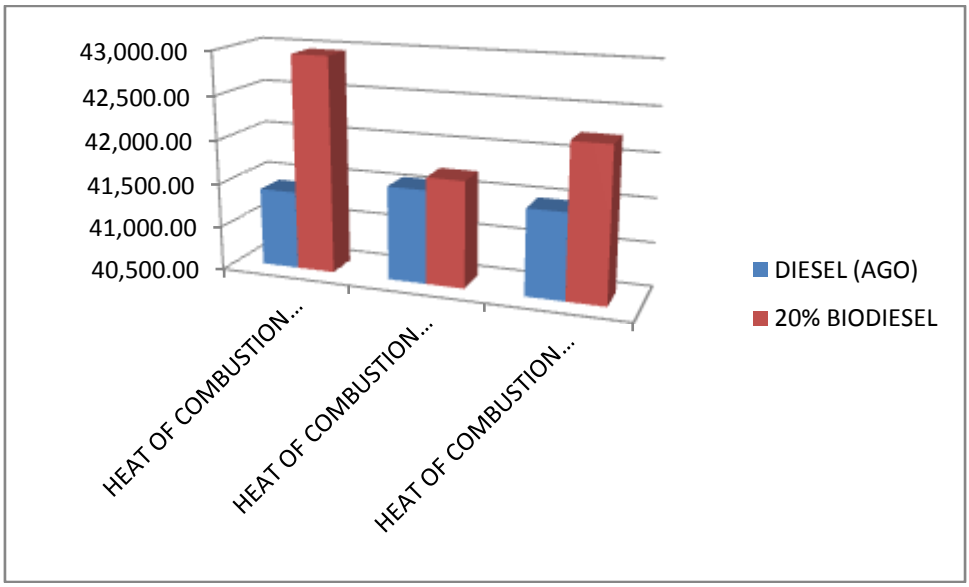

Fig 5.0 Bar Graph of Heat of Combustion of AGO versus 20% blended Biodiesel

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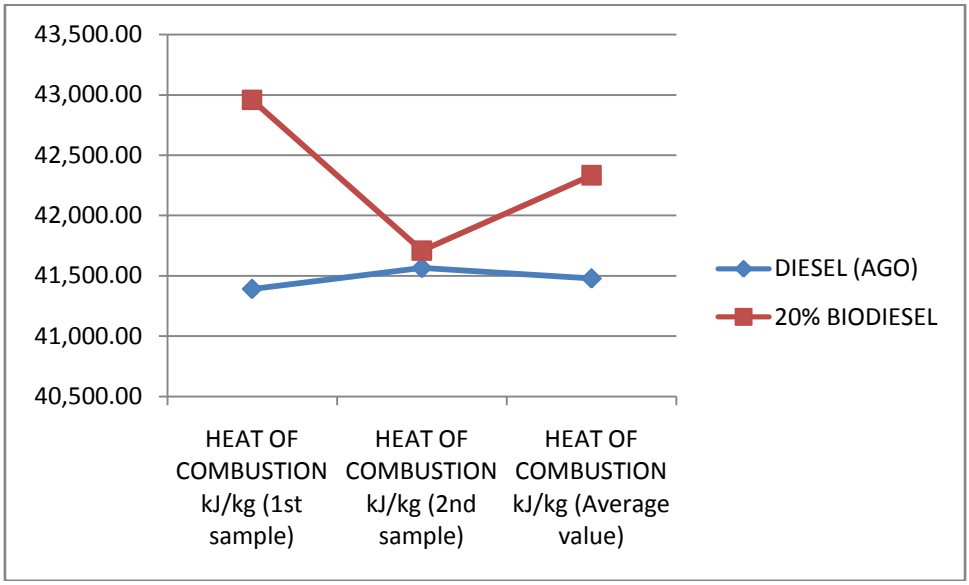

Fig 6.0 Line Graph of Heat of Combustion of AGO versus 20% blended Biodiesel

MATLAB EVALUATION OF VARIANCE AND STANDARD DEVIATION OF HEAT OF COMBUSTION OF DIESEL(AGO) AND BLENDED BIODIESEL

```
>> A = [41391.30; 41565.20];
>> B = [42956.52; 41708.79];
>> var(A,B)

ans =

  7.5587e+03

>> std(A,B)

ans =

  86.9406
```

IV. DISCUSSION

The comparative property analysis of biodiesel blended with AGO and petroleum diesel (AGO) was investigated. According to **Table 1.0 and Fig 1.0to Fig 3.0**, the relative density or specific gravity of AGO or petroleum diesel was found to be 0.8709 with that of 20% blended biodiesel with AGO being 0.8735 at 15℃. These results indicated that AGO blended with 20% biodiesel has relative density closer to natural petroleum diesel.

Higher density nature of petroleum diesel (AGO) accounts for rapid air pollution due to particulate emission during combustion of diesel. Therefore, to minimize air pollution arising from petroleum diesel combustion, diesel (AGO) could be blended with biodiesel at rates below 20% to lower the relative density or specific gravity. This finding was also in line with Demshemino et al, (2013)which stated that blending biodiesel with petro-diesel at various ratios, leads to a decrease in theamount of particulate matter being emitted as the amount of biodiesel is increased in the blend fromB0 to B10.

Also, the kinematic viscosity of petroleum diesel (AGO) was found to be 4.9 centistokes whereas that of AGO blended with 20% biodiesel was 6.02 centistokes at 40℃. These results showed that AGO blended with 20% biodiesel offers higher internal resistance to flow compare to petroleum diesel. The flash points and pour points for the two fuel samples were found to be same, 126.7℃ and < -26℃ respectively.

In addition, MATLAB evaluation of variance and standard deviation of heat of combustion of diesel(AGO) and 20% blended biodiesel was also carried out. The variance was found to be **7,558.70kJ/kg** while standard deviation was found to be **86.9406.**

Furthermore, according to **Table 2.0 and Fig 4.0 to Fig 6.0**, the average heat of combustion of AGO or petroleum diesel was found to be**41,478.30 kJ/kg**with that of 20% blended biodiesel with AGO being **42,332.61 kJ/kg.**These results revealed that blending petroleum diesel (AGO) with biodiesel increases heating value above that of natural diesel, AGO. Thus, blends are good fuels with zero starting problems even in winter period. This type of increased heating value in addition to the lubricity effect of biodiesel would

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be of added advantage to the performance and durability of diesel engines.

V. CONCLUSION

Comparative property analysis of biodiesel blended with AGO and petroleum diesel (AGO) was successfully achieved.According to the findings, it can be deduced that petroleum diesel (AGO) blended with 20% biodiesel is an alternative fuel that can be used in a diesel engine. It has the potential of replacing petroleum diesel in the future, due to higher heating value, to improve performance and reduce toxic exhaust emissions. However, there would be need to redesign fuel injector, pump system and fuel flow lines to accommodate higher internal resistance to flow offered by the alternative fuel.

RECOMMENDATIONS

The following recommendations are suggested based on the study:

1) Minimize air pollution arising from petroleum diesel combustion; diesel (AGO) could be blended with biodiesel at rates below 20% to lower the relative density or specific gravity of aromatic compounds.
2) There would be need to redesign fuel injector, pump system and fuel flow lines to accommodate higher internal resistance to flow offered by the alternative fuel.
3) This research can also be done in the future using other biodiesel blends such as 5%, 10%, 15% and 30% respectively for generalization.

LIMITATION OF THE STUDY

In the course of carrying out this research, comparative property analysis of biodiesel blended with AGO and petroleum diesel (AGO),the researchers encountered many hindrances which might cause deviations from actual results. Some of the hindrances includes: design and fabrication difficulties, cost of data analysis, lack of electricity, material sourcing, etc.

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DISCLOSURE OF CONFLICT OF INTEREST

This research article is original and the corresponding author hereby confirms that co-author participated actively in the development of the paper and has read and approved the manuscript with no ethical issues and with declaration of no conflict of interest.

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