



## Emissions Characteristics of Biodiesel Blends From Yellow Oleander (*Thevetia peruviana*) Seed Oil

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### ABSTRACT

The emissions characteristics of Yellow Oleander seed oil biodiesel and its blends with conventional diesel were evaluated. This was done by running a stationary single-cylinder, 4-stroke air cooled diesel engine at varied torques of 2 Nm, 4 Nm, 6 Nm, 8 Nm, and 10 Nm on, first 100% diesel (D100), then 100% biodiesel (B100), and, subsequently, on blends of the biodiesel with the diesel in the proportion by volume of 30% biodiesel (B30); 20% biodiesel (B20); and 10% biodiesel (B10). The emissions of unburnt Hydrocarbons, HC; Carbon IV oxide, CO<sub>2</sub>; Carbon II oxide, CO; and oxides of Nitrogen, NO<sub>x</sub> were measured at these engine load torques. Results showed that, over the entire engine load, the B100 had the lowest mean emission of unburnt hydrocarbon at 11.6 ppm – about 18% lower than that emitted using D100 which was 14.2 ppm; B10 had mean emission of HC of 14.2 ppm – about 3% higher than that of D100; and B30 and B20 also had lower HC emissions than D100 at 13.6 ppm and 12.6 ppm, respectively – with the later having the lowest HC emission of 8 ppm at a torque load of 10 Nm – while B10 had near identical mean emission with D100 at 14.6 ppm. B100 also had the lowest mean emission of NO<sub>x</sub> at 222.6 ppm (about 14% lower than that of D100 at 258 ppm), whereas all the other blends had NO<sub>x</sub> emissions higher than that of D100 (B30: 261 ppm; B20: 273.4 ppm; and B10: 262.6 ppm). Again, B100 had the lowest mean emission of CO of about 0.01% – representing about two times lower than that of the D100 at 0.02%; CO emissions for B30 and B10 were both 0.018% each – about 10% lower than that of D100 – while that of B20 was 0.022% – 10% higher than that of D100. As for the CO<sub>2</sub> emissions, the B100 again had the least mean emission at 3.53% – representing about 3% lower than that of the D100 at 3.65%; B30, B20 and B10 all had CO<sub>2</sub> emissions higher than that of D100 at 3.66%, 3.70% and 3.70%, respectively. The study concluded that, with only slight differences in the emission characteristics between the D100 and the blends, particularly for unburnt hydrocarbons, the blends of Yellow Oleander seed oil biodiesel with conventional diesel could be used as partial replacement for diesel fuel in Compression Ignition Engines.

**Keywords:** Yellow Oleander, Biodiesel, Engine torque, Hydrocarbons

### INTRODUCTION

Utilisation of biodiesel as an alternative and renewable fuel for compression ignition (diesel) engines has now become a subject or research in this area. Emissions from the diesel engine when run on conventional diesel include gaseous irritants and Greenhouse Gases (GHG) which pollutes the air and endangers health and the environment; this has led to increasing stringent regulations imposed on diesel engine exhaust gas emissions (Mofijur *et al.*, 2018) by International regulating bodies.

The main attraction of biodiesel is its potential to produce significantly lower well-to-wheel

CO<sub>2</sub> emissions than that produced by conventional (fossil-based) diesel. Biodiesels are also biodegradable, have low toxicity and can blend in significant proportion with existing fuel pool with little or no modification to the vehicle engines, (Srithar *et al.*, 2017). However, the greenhouse gas (GHG) emissions savings of biodiesel can be eroded if feedstock oils that lead to unsustainable utilisation of forest resources are used for its production (Habibullah *et al.*, 2015).

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*Thevetia peruviana* (yellow oleander) is a nonedible plant that is grown in Nigeria and many other parts of the world as hedges and as ornamental plant in landscaping. It has a high level of oil content in its kernel (about 60-65%) and valuable protein content in the seed (about 40-45%), and it is nonedible because of its toxicity. Hence, while the plant remains a plant of no significant value for food applications, the oil from the plant can potentially be used for biofuel product (Godson & Bassey, 2015).

Biodiesels can reduce Greenhouse Gas (GHG) emissions significantly, compared to conventional diesel, since biodiesels produced from plants oils have carbon neutrality in their life cycle as they consume the Carbon IV Oxide ( $\text{CO}_2$ ) produced by the combustion of biodiesel and, hence, do not contribute to the net increase in  $\text{CO}_2$  going into the atmosphere, (Bari and Hossain, 2018). The use of 100% biodiesel, however, is not encouraged because it has been found that because of the chemical nature of biodiesel, oxidation and corrosion processes can increase the level of wear engine parts; the high temperature of combustion of the biodiesel increases its acidity and enhances the tendency of chemical reaction between the biodiesel and the surface of the injection nozzle, among other drawbacks, (Celik and Aydin, 2011).

This work assessed the Greenhouse Gases emissions pure biodiesel produced from yellow oleander seed oil and from its various blends with conventional diesel.

## METHODOLOGY

### Materials

These include pure conventional diesel fuel (D100); pure Yellow Oleander Seed oil biodiesel, i.e., 100% biodiesel (B100); 30 vol% biodiesel in diesel (B30); 20 vol% biodiesel (B20) in diesel; and 10 vol% biodiesel (B10) in diesel.

The engine used was a horizontal single-cylinder 4-stroke air cooled diesel engine, Model 165F, with a power range of 2.5 to 7.5 kW, maximum torque of 12 Nm; maximum speed of 6000 rpm, and maximum specific fuel consumption at rated output of 284.2 g/kWh, and equipped with a dynamometer and instrumentation units.

A Nanhua model NHA-506EN exhaust gas analyser was used to measure the concentration of HC, CO,  $\text{CO}_2$  and NOX contained in exhaust gases from the engine. It displays the results on an LCD screen.

### Methods

Experiments were carried out by running the engine on, first, pure conventional diesel fuel (D100) to generate the base line data and, subsequently, on B100, B30, B20 and B10 blends of biodiesel with conventional diesel fuel. The engine speed was measured at the torque settings of 2, 4, 6, 8 and 10 Nm in order to measure the parameters related to the engine exhaust emissions

On each torque setting on the engine, emission gases,  $\text{NO}_x$ , HC, CO and  $\text{CO}_2$ , were measured using the exhaust gas analyser which was placed at the exhaust of the engine.

## RESULTS AND DISCUSSIONS

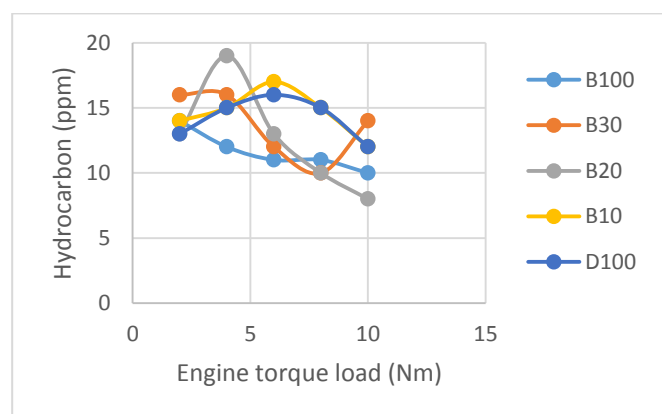


Figure 1: Variation of unburnt hydrocarbon emissions with torque for different biodiesel blends

According to Gopal and Karupparaj (2014), unburnt hydrocarbon (HC) pollutants result from incomplete combustion of hydrocarbon fuels and it is one of the important parameters used to characterise the emission behaviour of diesel engines. The variation of hydrocarbons emissions with torque for the different fuel blends is presented in Figure 1. Generally, B100 has lower hydrocarbon emissions than D100. B10 however has very similar hydrocarbon emissions to D100 at all torques – except at 6 Nm, where its emissions were slightly higher. B20 and B30 have emissions

level between those of D100 and B100. It is noted however that B20 has a higher emission than all the fuel blends at 4 Nm. It is possible that this point is an outlier. It can also be seen from the figure that while D100 and the other blends show varying emissions as the torque increased, the emissions of the pure biodiesel (B100) monotonously decreased with increasing torque.

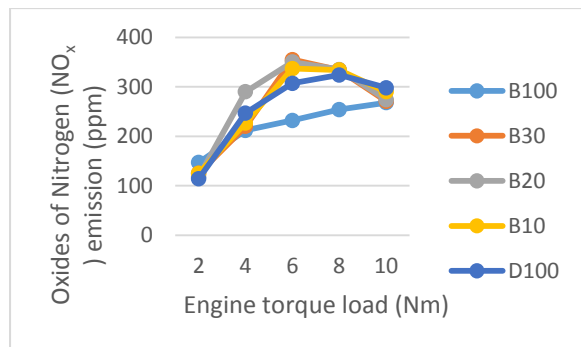


Figure 2: Variation of NO<sub>x</sub> emissions with torque for different biodiesel blends

The Variation of NO<sub>x</sub> – which, according to Bari and Hossain, 2018, is a general representation of NO and NO<sub>2</sub> – emissions with torque for different biodiesel blends are shown in Figure 2. It is observed that at the initial torque of 2 Nm, D100, B20 and B30 have almost the same NO<sub>x</sub> emissions while B100 has the highest NO<sub>x</sub> emissions. At higher torques, B100 has lower emissions than D100. The blends (B10, B20 and B30) have higher NO<sub>x</sub> emissions than B100 while the emissions of D100 are intermediate between those of B100 and the other blends. Generally, biodiesels usually have higher NO<sub>x</sub> emissions than the conventional diesel because of the presence of oxygen molecules in the biodiesel molecule, (Bari and Hossain, 2018).

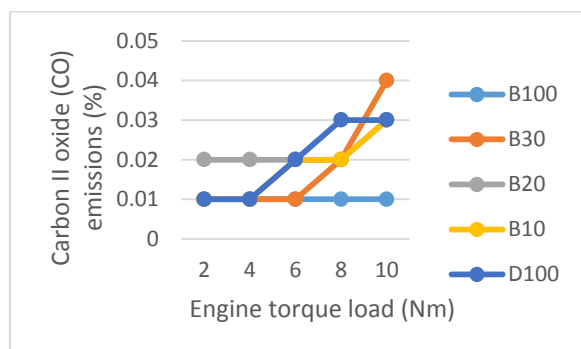


Figure 3: Variation of CO emissions with torque for different biodiesel blends

According to Gopal *et al* (2014), Carbon II oxide (CO) is one of the intermediate compounds formed during the intermediate combustion stage of hydrocarbon fuels and its formation depends on, among other factors, the air-fuel equivalence ratio, engine speed and combustion chamber design. Figure 3 shows the variation of CO emissions with torque. In general, the CO emissions of B100 appeared to be independent of torque while the emissions of the other blends increased with torque. There are different threshold values at which the emissions start to increase. For example, the emissions of B30 appeared to be independent of the torque until it is increased above 6 Nm, at which point the emissions increased at a faster rate than those of the other blends.

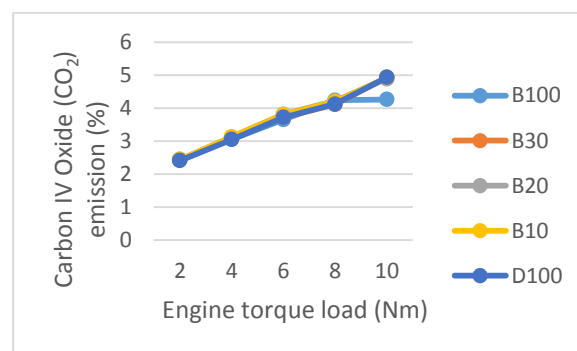


Figure 4: Variation of CO<sub>2</sub> emissions with torque for different biodiesel blends

Figure 4 shows the variation of carbon IV oxide (CO<sub>2</sub>) emissions with torque for the different blends. For all the fuel blends, CO<sub>2</sub> emissions increased as the torque increased and all the fuel blends have emissions values that are close to one another. B100 however appeared to have lower CO<sub>2</sub> emissions than the rest of the blends at a torque of 10 Nm.

### Conclusion

The following conclusions can be drawn from the results of the engine emissions tests conducted on the blends of the biodiesel from the yellow oleander seed oil. Within the range of engine torque biodiesel blends used:

- Although B100 has the lowest mean emission of unburnt hydrocarbon compared to that of D100, B20 has the lowest mean unburnt hydrocarbon emission characteristics.
- Except for pure biodiesel, all blends of biodiesel emit more NO<sub>x</sub> than the pure

conventional diesel, while B30 has the least mean emission of NOx.

- iii. The CO emissions of B100 is independent of torque (and with overall least mean emission) while the emissions of the other blends increased with torque. However, mean CO emissions from B10, and B30 were slightly less than that from D100, represent the best choice among the blends.
- iv. Again, B100 had the least mean CO<sub>2</sub> emissions whereas CO<sub>2</sub> emissions for all other blends were slightly higher (compared to that from D100). B30 again represent the optimum for the blends.
- v. Therefore, with the rang of engine load torque and biodiesel blends used in this work, since the pure biodiesel (B100) is not recommended for use because of the associated engine problems likely to result, B30 yellow oleander biodiesel-diesel blend represent the best choice for emission consideration

### Recommendations

For efficient use of biodiesel as a renewable fuel, further work can be done in the following areas:

- i. Further research into the optimization of Yellow Oleander seed oil biodiesel blends that can yield the best combination of Greenhouse Gases emissions.

### REFERENCES

- Bari, S. and Hossain, S. N. (2019). Performance and Emission Analysis of a Diesel Engine Running on Palm Oil Diesel (POD). 2<sup>nd</sup> International Conference on Energy and Power, ICEP2018, Sydney, Australia. *Energy Procedia* 160 (2019), pp 92 – 99.
- Celik, I and Aydin, O. (2011). Effects of B100 Biodiesel on Injector and Pump Piston. *Tribology Transactions*, Vol. 54, pp 424 – 431.
- Godson A. R. E. and Basse U. G. (2015), Characterization of Oil and Biodiesel Produced from *Thevetia peruviana* (Yellow Oleander) Seeds. *International Journal of Sustainable and Green Energy*; 4(4): 150-158.
- Gopal, K. N. and Karupparaj, R. T. (2014). Effect of Pongamia Biodiesel on Emission and Combustion Characteristics of DI Compression Ignition Engine. *Ain Shams Engineering Journal*. Volume 6, pp 297 – 305.
- Gopal, K. N., Pal, A., Sharma, S., Samanchi, C., Sathyanarayanan, K. and Elango, T. (2014). Investigation of Emissions and Combustion Characteristics of a CI Engine Fuelled with Waste Cooking Oil Methyl Ester and Diesel Blends. *Alexandria Engineering Journal*. Vol. 53, pp 281 – 287.
- Habibullah, M., Masjuki, H. H., Kalam, M. A., Ashrafur Rahman, S. M., Mofijur, M., Mobarak, H. M. and Ashraful. A. M. (2015). Potential of biodiesel as a renewable energy source in Bangladesh. *Renewable and Sustainable Energy Reviews*, 50, 819 - 834.
- Mofijur M., Rasul, M., Hassan, N. M. S., and Uddin, M. N. (2019). Investigation of Exhaust Emissions for a Stationary Diesel Engine Fuelled with Biodiesel. 2<sup>nd</sup> International Conference on Energy and Power, ICEP2018, Sydney, Australia. *Energy Procedia* 160 (2019), pp 791 – 797.
- Srithar, K., Balasubramanian, K. A., Pavendan, V. and Kumar, B. A. (20117). Experimental Investigations on Mixing of Two Biodiesels Blended with Diesel as Alternative Fuel for Diesel Engines. *Journal of King Saud University – Engineering Sciences*. Vol. 29, pp 50 – 56.