Comparison of camphor and fuel injector cleaner effects on the performance and emission levels of gasoline engines

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ABSTRACT

In this research, injector, cleaner and camphor were blended with premium motor spirit (PMS). The physicochemical properties and eff ects on the performance and exhaust emission levels of spark ignition engines were investigated. Samples with injector cleaner showed the best physicochemical properties relative to the sole petrol and camphor blended samples; these specimens had densities of 0.72706 kg/m2 (I5), flashpoints of 47 °C for I5, I10, and I15 and 48 °C by I25, and viscosities of 1.7. A performance analysis showed that I25 at 3 Nm had specific fuel consumption levels of 45.51 kgkwh-1 and 27.2 kgkwh-1, which were the best recorded among all the samples; additionally, the sample I25 showed the lowest emissions of CO and CO2 at 0.2% and 0.13% at 3 Nm and 6 Nm, respectively, for CO emissions and at 1.22 and 1.47% at 3 Nm and 6 Nm, respectively, for CO2 emissions. Concerning NOx emissions, sample I25 showed the best results, with the highest NOx emission reductions of 312 and 342 ppm at 3 and 6 Nm engine torques, respectively. With this information, it was concluded that cleaner injector blends were better than camphor blends.

Keywords: Petrol; Camphor; Emissions; Blends; Physiochemical Properties; Gasoline; Injector cleaner.

INTRODUCTION

Improving the quality of fuels has been an interesting research subject for scientists, especially in recent years, and several studies have aimed to improve both engine performance and reduce engine emissions. Some of these works have been specifically carried out to investigate the prospects of blending fuels with some additives or other fuels with similar or improved properties (Ashok, B., Jeevanantham, A. K., Nanthagopal, K., Saravanan, B., Senthil Kumar, M., Johny, A., Mohan, A., Kaisan, M. U., & Abubakar, S. 2019). Kaisan et al. examined and compared the effects of propanol and camphor on spark-ignition engine performance and emission levels (Kaisan, M. U., Pam, G. Y., & Kulla, D. M. 2013). The findings showed that Sample P0B (100% pure gasoline and 5 g camphor) had the best physicochemical properties. The fuel properties of the blend were improved by the addition of 5 g camphor as an additive. The results showed percentage increases of 0.5% for the specific gravity, 30.8% for the viscosity, 5.08% for the fire point, and 21.8% for the flashpoint. The results showed improvements in the engine brake thermal efficiency, specific fuel consumption, and engine brake power levels. In similar research, Kaisan et al. investigated the effects of camphor and butanol on engine performance and emission levels (Kaisan, M.U., Sanusi, A., Ibrahim, I. U., & Abubakar, S. 2020). This research showed that the addition of 5 g of camphor was the best for improving both the fuel physicochemical properties and engine performance levels relative to the addition of butanol; however, the engine emissions were reduced with the addition of butanol.

Higher alcohol fuel was intensively used in research to ascertain its influences on engine performance and emission levels. The effects of iso-butanol blended with gasoline were studied on SI engines. The results showed that brake power, exhaust gas temperature, and in-cylinder pressure decreased for blends with 3, 7 and 10% by volume iso-butanol in gasoline relative to pure gasoline without engine optimization (Kaisan, M.U., Sanusi, A., Ibrahim, I. U., & Abubakar, S. 2020). The researchers investigated the effects of higher alcohols (1-butanol and 2-propanol) blended with rapeseed oil on a diesel engine at proportions of 10% and 20% to reduce the viscosity. The results showed that both affected engine emissions; notably, NOx emissions were reduced with butanol and increased with 2-propanol. The combustion process results showed that alcohol blends reduced the length of the diffusion phase while increasing the combustion kinetic intensity. Kaisan studied the effects of using dual n-butanol and iso-butanol additives on spark-ignition engine performance and emission levels over single alcohol and neat gasoline blends; n-butanol and iso-butanol were blended with gasoline separately, and another sample featured blends of n-butanol and iso-butanol with gasoline. The results showed that a dual alcohol blend had the best engine performance among all the options, including blends with single alcohols. The researchers studied the effects of butanol when blended with gasoline in a single-cylinder engine run between speeds of 6500 and 8500 rpm. The results showed that the butanol–gasoline blend increased the knocking resistance by allowing advanced ignition timing in SI engines, leading to more efficient combustion. Blends with higher percentages and optimum spark ignition timing resulted in lower HC, CO, and oxygen (O2) emissions than blends with little to no butanol volume percentage; however, NOx and CO2 emissions were significantly higher for these blends than for pure gasoline. In terms of basic exhaust gas emissions, ternary blends increased nitric oxide (NO) and carbon monoxide (CO) emissions while reducing hydrocarbon (HC) and carbon dioxide (CO2) emissions relative to diesel. Some researchers used ethanol–gasoline (E5 and E10) and methanol–gasoline (M5 and M10) fuel blends on SI engine runs at different vehicle speeds of 80 km/h and 100 km/h and compared the results with gasoline fuels (Eyidogan et al., 2010). The results indicated that when alcohol–gasoline fuel blends were used, the brake specific fuel consumption increased, and the cylinder gas pressure started to increase under almost all test conditions. The lowest peak heat release rate was obtained from gasoline fuel use. Some researchers studied the potential of using biodiesel as an alternative fuel with biodiesel from cottonseed oil and observed that pure diesel was thermally more efficient than biodiesel blends at low torque; however, biodiesels tended to have higher engine brake power (I. A. Hussain, I. U. Ibrahim, 2020). Five samples with different compositions of the n-pentanol fraction (10%, 20%, 30%, 40%, and 50%) by volume were used. The findings showed that the brake thermal efficiency improved by approximately 30% relative to pure diesel, with the specific fuel consumption of biodiesel-pentanol blends increasing from 4.2% to 27.3% relative to diesel fuel (D100).

Metallic additives have been investigated, and their influences on improving fuel quality, engine performance, and emissions have been reported in many research reports. Biodiesels from waste cooking oils were mixed with mineral diesel in proportions of 20:80 with cerium oxide nanoparticles as an additive, and the findings revealed that nanoparticle addition of cerium oxide (CeO2) improved engine combustion characteristics; that is, it increased the peak pressure and heat release rate. Notably, the best engine performance was observed at an injection pressure of 240 bar with an 80 ppm nanoparticle concentration. In terms of hydrocarbon emissions, nitrogen oxides and smoke decreased at relatively high injection pressures with nanoparticle addition.

The use of camphor and injector cleaner on SI engines has been widely reported by vehicle users, especially in Nigeria, with different accounts of their influences on engine performance levels. Very few studies are available on their use as fuel additives. In this research, efforts are made to investigate the effects of both camphor and injector cleaner on engine performance and emission levels and to compare the two to ascertain the best additive that improves the fuel quality, engine performance, and emission levels.

Sample preparation

Table 1 shows the compositions of various samples of blends.

Table 1. Sample Nomenclature

S/n	Nomenclature of samples	Compositions of samples		
		% of petrol per liter	% of fuel injector cleaner per sample	Amount of camphor (g)
1	CI0	100	_	_
2	C2	100	_	2
3	C4	100	_	4
4	C6	100	_	6
5	C8	100	_	8
6	C10	100	_	10
7	I5	95%	5%	_
8	I10	90%	10%	_
9	I15	85%	15%	_
10	I20	80%	20%	_
11	I25	75%	25%	_

EXPERIMENTAL PROCEDURE

The engine performance and emission test were conducted on a four-stroke, single-cylinder, spark-ignition engine, as shown in Figure 1. The engine was secured well to a test bench where its output shaft was coupled to the dynamometer rotor, utilizing mechanical friction for braking.

B. Engine test setup **A. Gas analyzer interface**

Figure 1. Experimental assembly for the performance and emission test

RESULTS AND DISCUSSION

Physicochemical properties of the samples

Tests of the physicochemical properties were conducted, where various properties, such as flash point, viscosity, density, acid value, cetane number, and iodine value, of the samples were tested. The results are presented and discussed below.

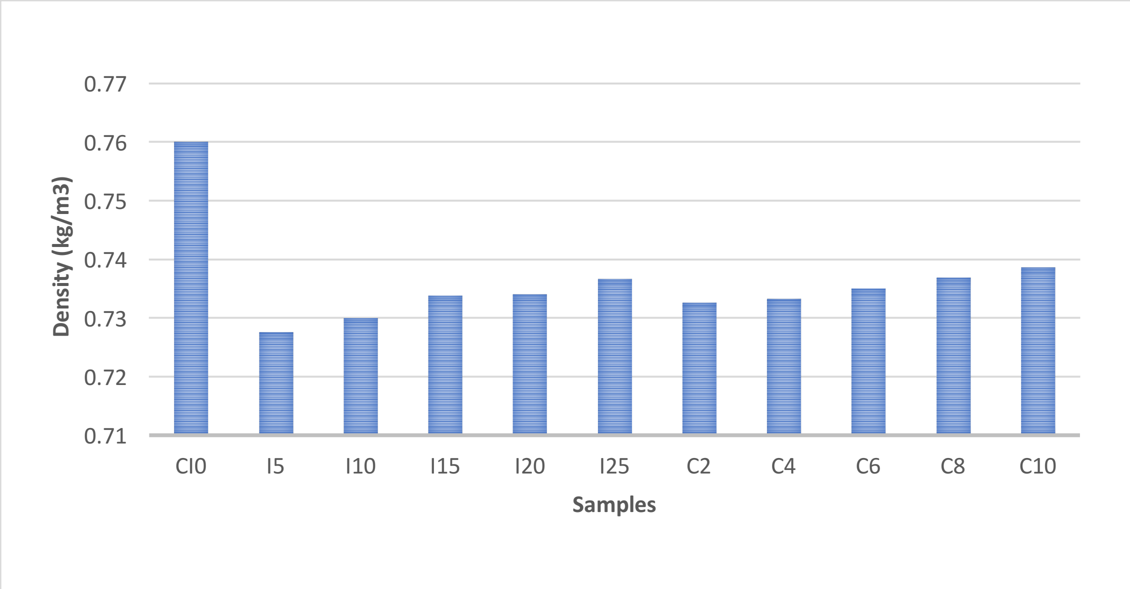

Figure 2. Densities of the samples

According to Figure 2, from all the samples, pure petrol (C10) appeared to have the highest density. Pollution emissions generally increased with increasing fuel density.

Viscosity

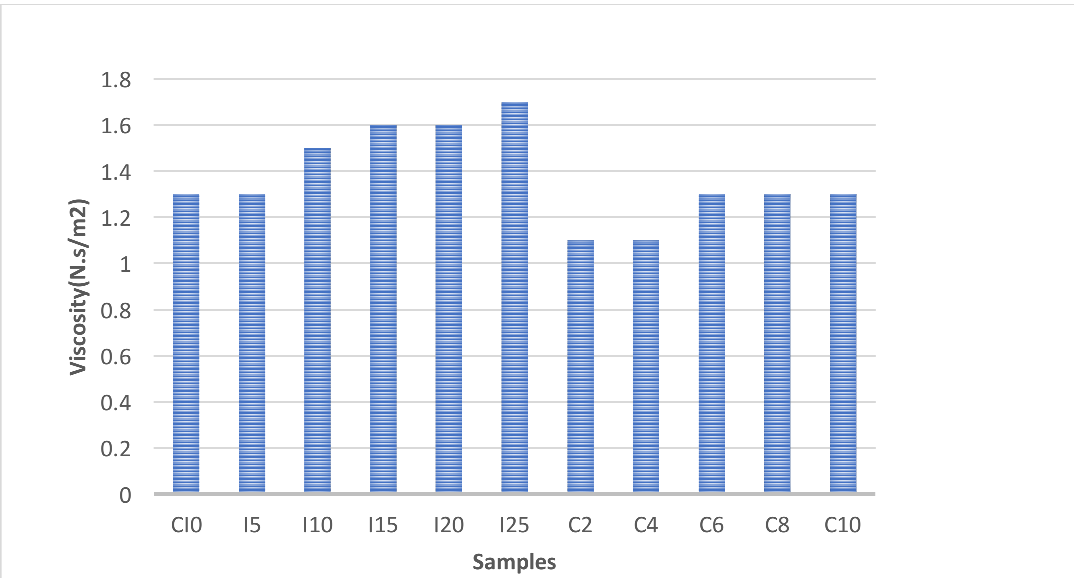

Figure 3. Viscosities of the samples

From Figure 3, the samples with the lowest viscosity were samples C2 and C4 relative to pure petrol (CI0), with a value of 1.3 $N.s/m^2$ and I25, with a value of 1.7 $N.s/m^2$.

Emission test results

Carbon monoxide (CO)

Carbon monoxide (CO) is normally produced in an internal combustion engine due to insufficient oxygen to produce carbon dioxide (CO2). The effect of camphor–injector cleaner–petrol blends on carbon monoxide (CO) emissions is shown in Figure 4.

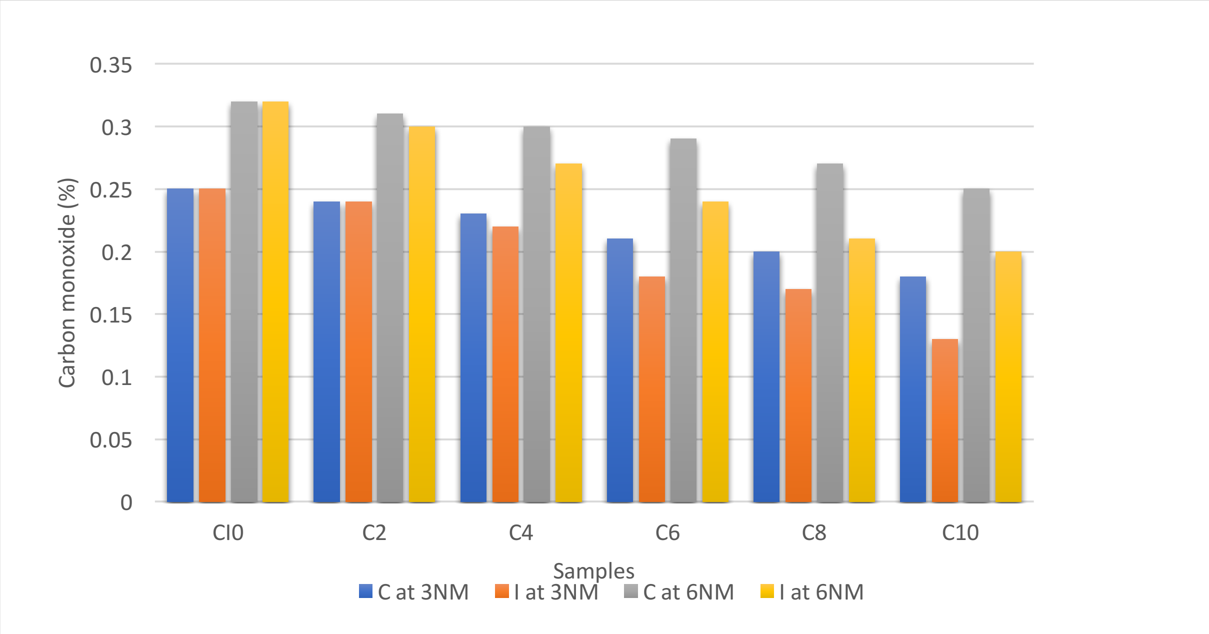

Figure 4. Carbon monoxide (CO) emissions

Figure 4 shows that the addition of camphor to the sole petrol in this ratio decreased the emission of carbon monoxide in both 3 Nm and 6 Nm torques applied to the petrol–injector blend. Finally, the best sample with the lowest emission of CO was I25, with CO emissions of 0.2% and 0.13% at 3 Nm and 6 Nm, respectively.

Carbon dioxide (CO_2)

The formation of carbon dioxide in the emitted gases indicated the complete combustion of the fuel in the combustion chamber. The effects of the camphor–injector cleaner–petrol blends on the CO2 are shown in Figure 5.

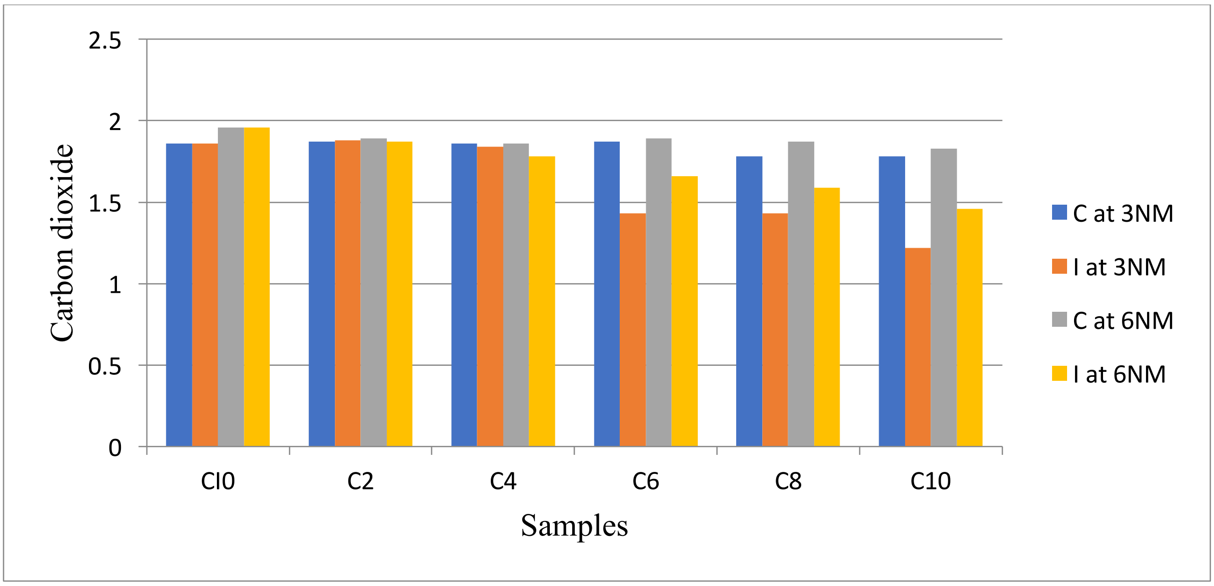

Figure 5. Carbon dioxide (CO_2) emissions of the samples at 3 and 6 Nm

Figure 5 shows that the higher the percentage of cleaner injectors was, the lower the amount of CO2 emitted. The higher the amount of camphor in the sample was, the lower the emissions of CO2. From the results, the sample with the lowest emission of CO2 for the two constant torques was sample I25, which had values of 1.22 and 1.46% of CO2 for 3 Nm and 6 Nm, respectively.

Hydrocarbons (HC)

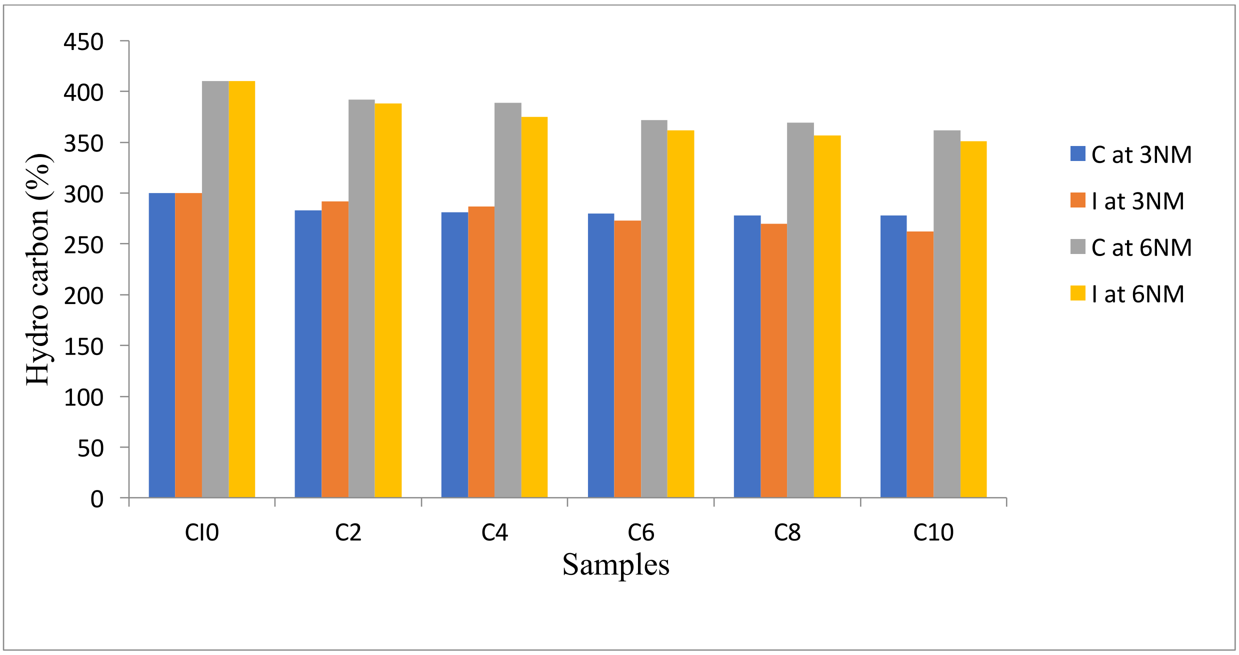

Figure 6. Hydrocarbon emissions

Figure 6 shows that as the percentage of injector cleaner in the blend sample increased, the amount of HC emitted decreased. Additionally, with the camphor blends, an increase in the amount of camphor in the sample was shown to reduce the emissions of HC. From the results, the sample with the least HC emissions at both torques (3 Nm and 6 Nm) was sample I25, which had HC values of 262 and 351 ppm for 3 Nm and 6 Nm, respectively.

Nitrogen oxide (NOx)

NOx is a generic term for the nitrogen oxides most relevant for air pollution, namely, nitric oxide (NO) and nitrogen dioxide (NO2). NOX is produced in the spark-ignition engine due to the combustion of air, which contains some percentage of nitrogen and oxygen. The effect of the camphor–injector cleaner–petrol blends on the emission of nitrogen oxide is shown in Figure 7.

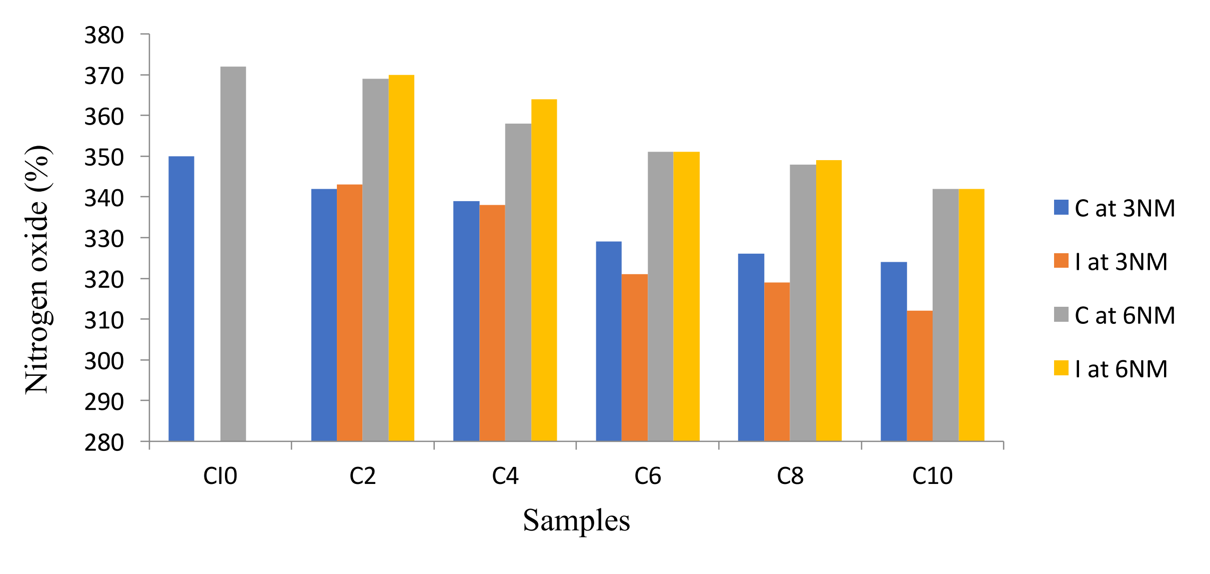

Figure 7. Nitrogen oxide (NO_x) emission of the samples at 3 and 6 Nm

Figure 7 shows that as the percentage of injector cleaner and camphor in the blend increases, NOX emissions decrease significantly; the amount of NOx emitted is insignificantly dependent on the torque run by the engine. Hence, from the results obtained, the sample with the lowest emission of NOx is sample I25, with values of 312 and 342 ppm at 3 Nm and 6 Nm, respectively.

CONCLUSION

Considering the experimental results and the detailed analysis of the results, sample I25 showed the best performance among all the samples treated in this experiment; it had the lowest emissions of CO and CO2, with 0.2% and 0.13% at 3 Nm and 6 Nm for CO emissions and 1.22 and 1.47% for CO2 at 3 Nm and 6 Nm, respectively. Regarding NOx emissions, sample I25 showed the best result, with the highest NOx emission reductions at values of 312 and 342 ppm at 3 and 6 Nm engine torque, respectively. The minimum specific fuel consumption was recorded among all the samples tested. This result showed that concerning CO, CO2, and NOx emissions and specific fuel consumption, the sample with the injector cleaner proved to be more effective than the sample with camphor.

REFERENCES

Ashok, B., Jeevanantham, A. K., Nanthagopal, K., Saravanan, B., Senthil Kumar, M., Johny, A., Mohan, A., Kaisan, M. U., & Abubakar, S. 2019. Experimental analysis on the effect of n-pentanol-Calophyllum Inophyllum Biodiesel binary blends in CI engine characteristics. Energy 173: 290-305. https://doi.org/10.1016/j.energy.2019.02.092.

Kaisan, M. U., Pam, G. Y., & Kulla, D. M. 2013. Physico-Chemical Properties of Bio-diesel from Wild Grape Seeds Oil and Petro-Diesel Blends. American Journal of Engineering Research 10:11-21.

Kaisan, M.U., Sanusi, A., Ibrahim, I. U., & Abubakar, S. 2020. Effect of Butanol and Camphor Blended with Premium Motor Spirit on Performance and Emission of Spark Ignition Engine:77-94.

Kaisan, M.U., Pam, G. Y., & Kulla, D. M. 2013. Physico-Chemical Properties of Bio-diesel from Wild Grape Seeds Oil and Petro-Diesel Blends. American Journal of Engineering Research 10:11–21.

Kaisan, M.U., Sanusi, A., Ibrahim, I. U., & Abubakar, S. 2020. Effect of Butanol and Camphor Blended with Premium Motor Spirit on Performance and Emission of Spark Ignition Engine 43: 77–94.

Kaisan, Muhammad Usman, Yusuf, L. O., Ibrahim, I. U., Abubakar, S., & Narayan, S.2020. Effects of propanol and camphor blended with gasoline fuel on the performance and emissions of a spark-ignition engine. ACS Omega, *5*(41):26454–26462.