Proceedings of the 2nd International Civil Engineering Conference on Innovation Technology in Civil Engineering: A Tool for Global Economy Recovery tagged NICE OSUN – CVE UNIOSUN 2025, Osun State University, Osogbo, Nigeria, 26th - 28th August 2025

INVESTIGATION OF THE EFFECT OF NANOPARTICLES ON THE PERFORMANCE OF BIOETHANOL PRODUCED FROM DRY MAIZE AND GUINEA CORN STALKS IN A POWER GENERATING SET

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ABSTRACT

The need for an alternative source of energy to replace fossil fuels that depletes the ozone layer causing climate change as led to several studies on the adaptation of biofuels such as bioethanol as a suitable replacement for gasoline in internal combustion engines. Studies have shown that bioethanol produced with nanoparticle catalysts performed better than bioethanol produced without nanoparticles as a catalyst. In this study, Aluminium oxide (Al_2O_3) nanoparticle was used to catalyze the fermentation of maize and guinea corns stalks respectively for the production of bioethanol. The results obtained revealed that the bioethanol produced from maize and guinea corns stalks performed better at 0.2 concentration of Aluminium oxide nanoparticle. The bioethanol produced from maize and guinea corn stalks with Aluminium oxide nanoparticles were then mixed with ratios of conventional gasoline at specific proportions. The bioethanol mixture with gasoline were then tested on an electric power generating set to determine the quantity of power output and performance of the bioethanol-gasoline mixtures for maize and guinea corn. The results obtained from the experimental tests that were conducted using the Sinwei electric power generating set showed that for the bioethanol produced from maize stalk that was mixed with conventional the E6 (94% gasoline mixed with 6% bioethanol) had the highest power output (40.86W) from the electric power generating set as measured by the digital multimeter. The performance analysis showed that the E5 (95% conventional gasoline mixed with 5% Bioethanol produced from maize stalk) had the highest running time of 260 seconds in the electric power generating set.

KEYWORDS: Bioethanol, Gasoline, Maize Stalk, Guinea Corn Stalk, Power, Performance, Generator

1. INTRODUCTION

The need for energy is rising throughout the world, particularly for petroleum fuels. Faced with rising petroleum fuel use and increasingly rigorous emission laws, biofuels such as ethanol have been investigated to reduce fuel consumption and engine emissions. Many studies on the use of ethanol in engines have focused on three aspects: ethanol application techniques on spark ignition engines, fuel properties of ethanol-gasoline blends, and effects on the combustion and exhaust characteristics of ethanol-gasoline blends (Iodice and Cardone, 2021). Hansen *et al.* (2005) established the fact that the mixtures bioethanol is regarded as one of the most promising renewable alternative fuels. Bioethanol may be fermented and distilled from sugarcane and grain, as well as cellulosic resources including wood, agricultural solid wastes, coal, sweet sorghum, and so on, and it has the potential to reduce CO, HC, NOx, and particle emissions. Bioethanol has various advantages over gasoline, including a higher octane number and flame speed, as well as a higher latent heat of vaporization and hence greater volumetric efficiency. It includes 35% oxygen, which aids in complete fuel combustion and so decreases dangerous exhaust emissions. Despite these benefits, bioethanol as a fuel is still not widely used due to technological limitations, economic and regional factors. Because of bioethanol's renewability and lower toxicity, utilizing bio ethanol gasoline blend is preferable than using pure gasoline from an environmental standpoint.

Nano-size materials have attracted huge interest for their unique material properties and their corresponding practical applications in biotechnology (Mujtaba, *et al* 2020). Nanoparticles (NPs) have been used extensively in biofuel, biomedicine, drug delivery, biosensors, water purification and environmental remediation (Razzaq *et al* 2021). The strategy of using nanobiocatalytic agents in bioprocesses is to increase process efficiency through increased mass and heat transfer, enzymatic and cell metabolic activities arising from their large surface areas, catalytic properties, growth and enzyme cofactor functionality (Gul *et al*, 2020). Nanoparticles are characterized as nanofibers, nanorods, nanowires, nanoclusters of metal and metal oxides, etc. These nanoparticles as nanocatalysts are different from conventional bulk catalysts in terms of their size that provides very large area-to-volume ratio and the resultant large active surface for chemical reaction to take place (Sirajunnisa and Surendhiran 2014). Application of nanoparticles during the alcohol production helps in improving the overall effectiveness of the process by increasing the efficiency of pretreatment, enzymatic hydrolysis, and increasing the reaction rate during the fermentation step. The major factors responsible for the generation of end products and permitting effective control of the reaction rate are particle size and morphology, surface area, nature of nanoparticles, and type of biomass utilized (Chaturvedi *et al.* 2012; Nbaba *et al.*, 2025). Metallic oxides of nanoparticles such as Iron Oxide nanoparticles, Zinc Oxide, nanoparticles and Nickel oxide nanoparticles have been used successfully to catalyze the production of bioethanol. Aluminium oxide nanoparticles have also found good in the production of bioethanol in recent years. It was the preferred nanocatalyst for this study. Awotunde et al. (2024) used Aluminium oxide nanoparticles to improve the physicochemical properties of bioethanol produced form maize and guinea corn stalks. In an earlier study, Awotunde et al. (2022) reported that the bioethanol produced from maize stalks had better physicochemical properties in comparison with bioethanol produced from guinea corn stalks.

2. MATERIALS AND METHODS

Some of the materials that were used in this study includes Dried grinded maize stalk dried grinded maize and guinea corn stalks, distilled water (20L), Guava leaves and palm wine (1L). In their study, Oyelaran *et al.* (2015) used waste paper and groundnut shell to produce binderless briquettes as an alternate source of energy for internal combustion engines with reasonable success. Thus, confirming the potentials of organic waste materials as sources of renewable energy.

Production of Aluminum Oxide Nanoparticle

Guava leaves were collected from a guava tree (as shown in Plate 1a) and washed with distilled water and it was dried under room temperature of 25℃ to 27℃. The dried guava leaves were grinded in to powder and stored in a dried container. The extraction of the phytochemicals from the grinded guava leaves was done using soxhlet extractor and ethanol as the solvent (as shown in Plate 1b). The extraction was done under reflux condition at a temperature of about 70℃ using a temperature-controlled heating mantle. The extracted phytochemical was collected into a beaker. 200g of aluminium oxide was mixed with 600g of the extracted phytochemical to synthesize the aluminium oxide nanoparticle at 60℃. Then Nano fluid was formed.

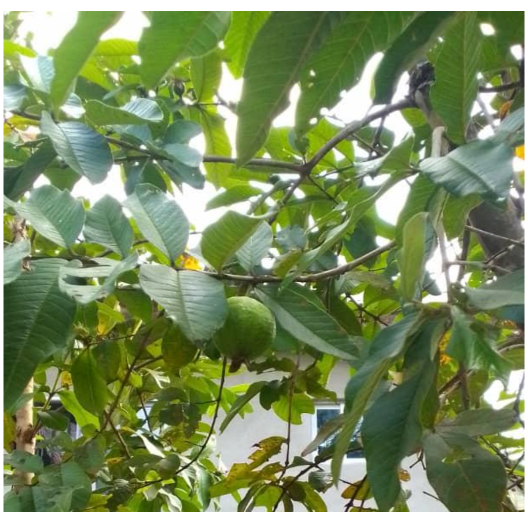

Plate 1a: Guava leaves (Source: Awotunde, 2024)

Plate 1b: Soxhlet apparatus

Collection of Maize Stalk and Guinea Corn Stalk

Fresh maize stalk and guinea corn stalk were collected from Owode farm, which is located in Ifon-Osun, Orolu local government area of Osun State, Nigeria. The stalk and leaf part were chopped, and sun dried to reduce the moisture. The dried sample were grounded by using a grinding machine. Grinding of sample into powder form was done to increase the surface area of the sample, which will enhance the contact between hemicelluloses and cellulose with dilute acid to reduce cellulose crystalline and remove lignin. The process is represented in Figure 1.

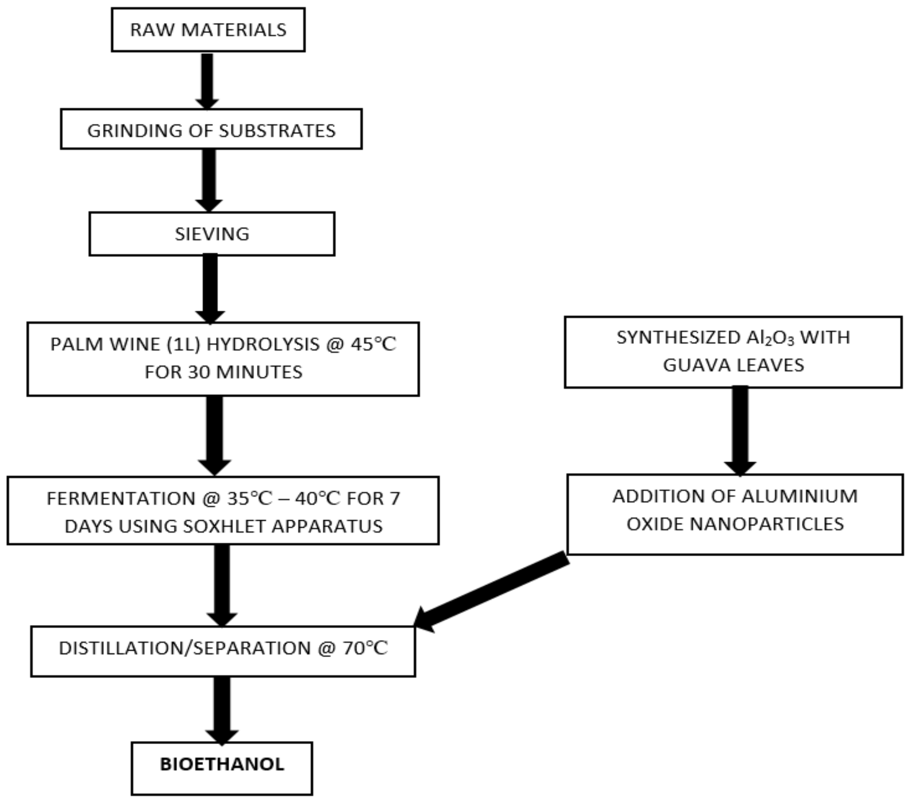

Figure 1: Framework of the lignocellulose of production of bioethanol

Experimental Set-up

The experiment was designed to determine the power output of the gasoline bioethanol mixtures in the electric power generating set (as specified in Table 1). Also, to determine the performance of each mixture of gasoline and bioethanol in the power generating through the time taken to burn out the gasoline-bioethanol mixture.

Table 1: Technical specification for the electric power generating set

Technical Specification	
Maximum Power	4.8 kW
Rated Power Output	4.5 kW
Voltage	230V
Manufacturer	Senwei LTD. China
Model	

Multimeter Specifications

The specification for the Multimeter that was used to measure the potential difference (Volts) and current produced by the electric power generating set is a Digital Multimeter, model: DT9205A. The circuit diagram is shown in Figure 2.

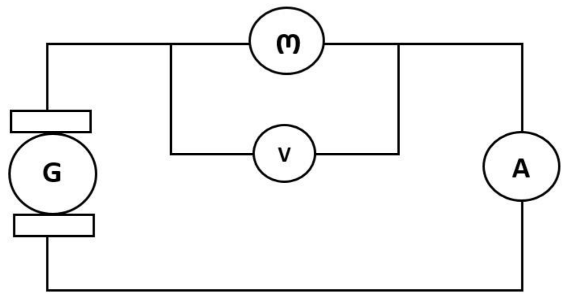

Figure 2: Circuit diagram for the experimental set up

Before the experiment proper was conducted, first the conventional gasoline (petrol fuel) was measured by proportion (40ml is equivalent to 100%). Same goes for the bioethanol produced from maize and guinea corn stalks respectively. Using standard laboratory burette, a 40ml sample of conventional gasoline was taken as 100% gasoline for the test. Based on the 40ml adopted standard, the corresponding quantity of maize and guinea corns stalk bioethanol were determined by volume proportion as follows (Table 2).

Table 2: Proportion by volume of conventional gasoline, Maize stalk bioethanol and Guinea corn stalk bioethanol respectively.

S/N	Conventional Gasoline		Bioethanol		
	(%)	By volume (ml)	(%)	By volume (ml)	Designation
1	100	40.0	0	0	E0
2	99	39.6	1	0.4	E1
3	98	39.2	2	0.8	E2
4	97	38.8	3	1.2	E3
5	96	38.4	4	1.6	E4
6	95	38.0	5	2.0	E5
7	94	37.6	6	2.4	E6
8	93	37.2	7	2.8	E7
9	92	36.8	8	3.2	E8
10	91	36.4	9	3.6	E9
11	90	36.0	10	4.0	E10
12	89	35.6	11	4.4	E11
13	88	35.2	12	4.8	E12
14	87	34.8	13	5.2	E13
15	86	34.4	14	5.6	E14
16	85	34	15	6.0	E15
17	84	33.6	16	6.4	E16

3. RESULTS AND DISCUSSION

3.1 Results of the Power Output and Performance of Bioethanol in Electric Power Generating set

The results obtained from the test conducted on the gasoline and bioethanol mixtures in the electric power generating set were presented in Tables 3 – 4 and Figures 3 – 6.

Table 3: Performance of the conventional gasoline and Bioethanol produced from Maize stalk in the electric power generating set.

S/N	E% (Bioethanol - Maize)	Voltage (V)	Current (I)	Time (s)	Power (W)
1	E0	226	0.22	212	49.72
2	E1	227	0.17	230	38.59
3	E2	227	0.18	235	40.86
4	E3	227	0.17	243	38.59
5	E4	225	0.18	215	40.50
6	E5	225	0.17	256	38.25
7	E6	227	0.18	235	40.86
8	E7	225	0.18	202	40.50
9	E8	226	0.18	224	40.68
10	E9	226	0.18	170	40.68
11	E10	226	0.18	212	40.68
12	E11	226	0.18	197	40.68
13	E12	225	0.18	175	40.50

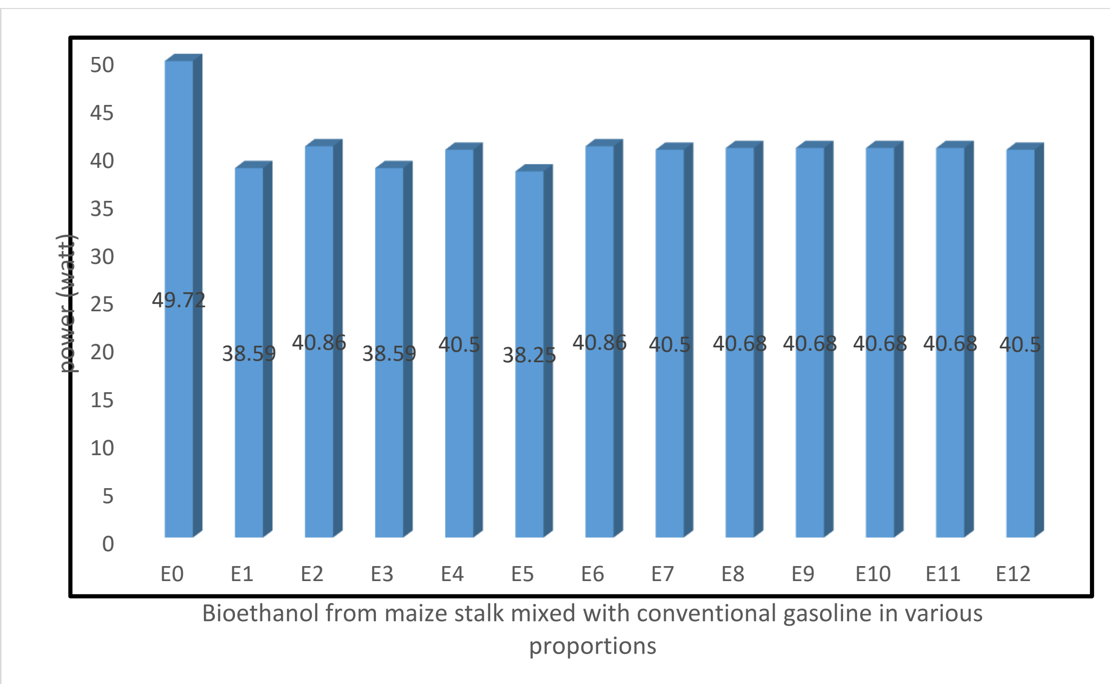

Figure 3: Power output for Bioethanol produced from maize stalk

Results of the power output of the bioethanol produced from maize stalk that was mixed with conventional gasoline showed that E6 (94% gasoline mixed with 6% bioethanol) had the highest power output (40.86W) from the electric power generating set as measured by the digital multimeter (Figure. 3).

The performance analysis showed that the E5 (95% conventional gasoline mixed with 5% Bioethanol produced from maize stalk) had the highest running time of 260 seconds in the electric power generating set (Figure 4).

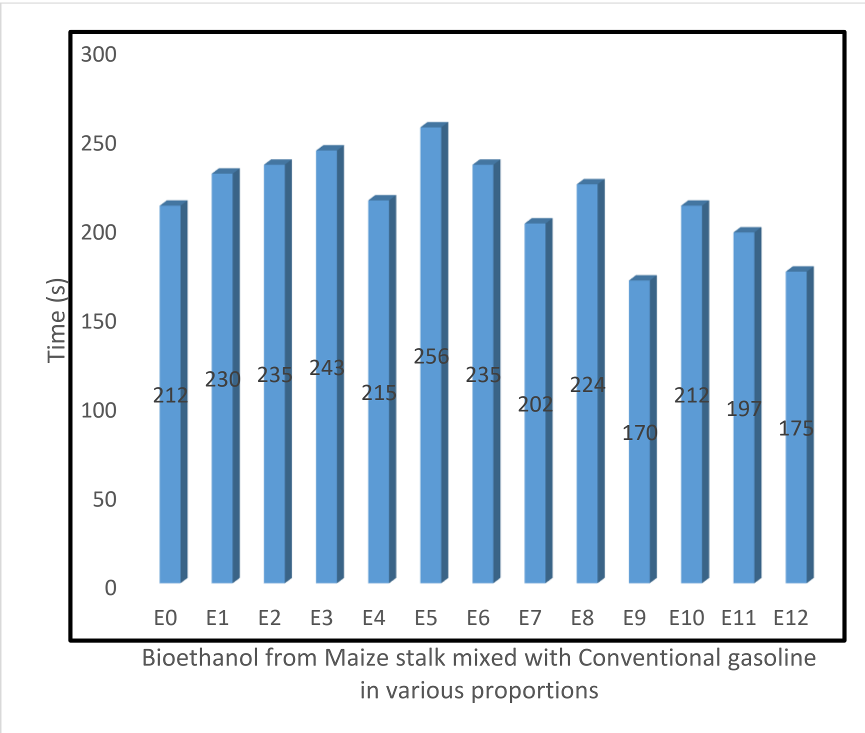

Figure 4: The time taken for each blended ratio of conventional gasoline and maize mixture to burn out in the electric power generating set

Table 4: Performance of the conventional gasoline and Bioethanol produced from Guinea corn stalk in the electric power generating set

S/N	E% (Bioethanol – Guinea corn)	Voltage (V)	Current (Amp)	Time (s)	Power (W)
1	E0	226	0.22	212	49.72
2	E1	225	0.16	172	36.00
3	E2	225	0.17	222	38.25
4	E3	225	0.17	227	38.25
5	E4	225	0.17	194	38.25
6	E5	229	0.18	180	41.22
7	E6	230	0.17	192	39.10
8	E7	227	0.16	220	36.20
9	E8	227	0.17	240	38.59
10	E9	227	0.16	180	36.20
11	E10	227	0.17	151	38.59
12	E11	225	0.16	144	36.00
13	E12	224	0.16	162	35.84

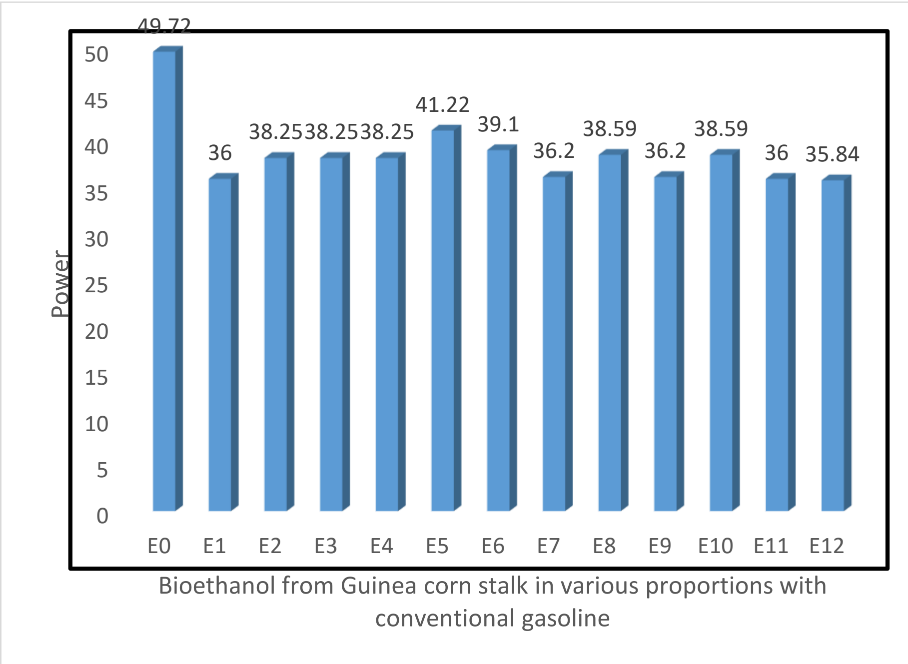

Figure 5: Power output for Bioethanol produced from Guinea corn stalk

According to Figure 5, E5 (95% conventional gasoline mixed with 5% bioethanol produced from guinea corn stalk had the highest power output (41.22W) of all the ratios of guinea corn produced bioethanol that was tested.

Results for the bioethanol that was produced from guinea corn also revealed that E8 (92% conventional gasoline mixed 8% bioethanol) had the highest running time of 240 seconds in the Sinwei electric power generating set. Other samples returned a shorter time for the same experiment (Figure 6).

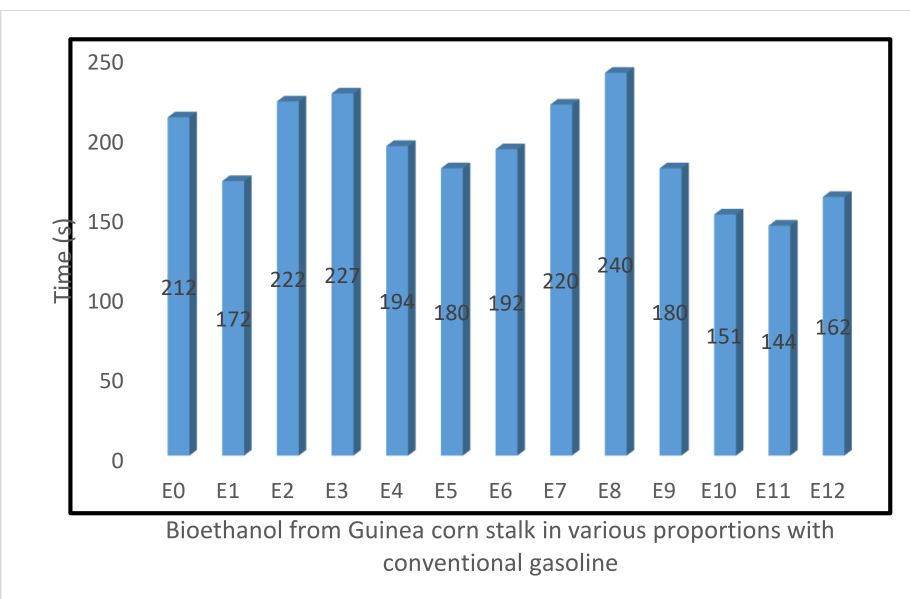

Figure 6. The time taken for each blended ratio of conventional gasoline and guinea corn mixture to burn out in the electric power generator.

The overall result from the experiments conducted with the bioethanol produced from maize and guinea corn stalks respectively revealed that lower levels of bioethanol by volume proportion to gasoline performed better in the electric power generating set as small proportions of bioethanol by volume that were mixed with gasoline burn longer as fuel in the generator. This is in tandem with the findings of Maarof *et al.* (2020). They submitted that engine performance using bioethanol blends was almost comparable to that of pure gasoline, especially at lower ethanol content blends (Maroof *et al.*, 2020).

3.2 Comparative analysis of Bioethanol produced from maize and Guinea corn stalks respectively with and without Aluminium oxide nanoparticles

The analysis of the produced bioethanol from maize and guinea corn stalks with and without Aluminium oxide nanoparticles are presented in Tables 5 and 6. The results showed that the bioethanol produced with the addition of Aluminium oxide nanoparticles performed better than the bioethanol produced without nanoparticles in the electric power generating set.

Table 5: Performance of Bioethanol produced without nanoparticle from maize and guinea corn stalks in an electric power generating set.

	Maize Bioethanol	**Maize Bioethanol**	**Guinea corn Bioethanol**	**Guinea corn Bioethanol**
E	E5	E3	E8	E7
P.D. (V)	227	226	226	227
Current (I)	0.13	0.13	0.13	0.12
Time (s)	216	175	255	211

Table 6: Performance of Bioethanol produced with nanoparticle (Al_2O_3) from maize and guinea corn stalks in an electric power generating set.

	Maize Bioethanol	**Maize Bioethanol**	**Guinea corn Bioethanol**	**Guinea corn Bioethanol**
E	E5	E3	E8	E7
P.D. (V)	225	227	227	227
Current (I)	0.17	0.17	0.17	0.16
Time (s)	256	243	240	180

Figure 7 showed that the maize produced bioethanol with Aluminium oxide nanoparticles (Al_2O_3 NPs) performed better in terms of the time spent burning inside the electric power generator in comparison with the bioethanol from maize that was produced without nanoparticles.

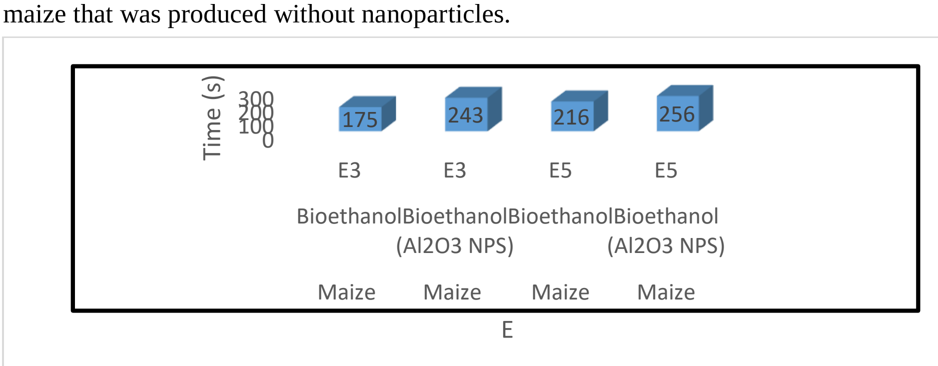

Figure 7: Comparison of the performance of the maize produced bioethanol (without nanoparticles) mixed with conventional gasoline with maize bioethanol produced with Aluminium oxide nanoparticles for E3 and E5.

The results revealed once again that the bioethanol that was produced with Aluminium oxide nanoparticles performed better in the electric power generator as they took longer time to burn out as fuel.

In Figure 8, it was indicated that the guinea corn produced bioethanol with Aluminium oxide nanoparticles performed less in comparison with that produced without nanoparticles when mixed with conventional gasoline and allowed to run in an electric power generating set. This showed that even with nanoparticles, bioethanol produced from guinea corn stalks has very poor physicochemical properties for internal engine combustion.

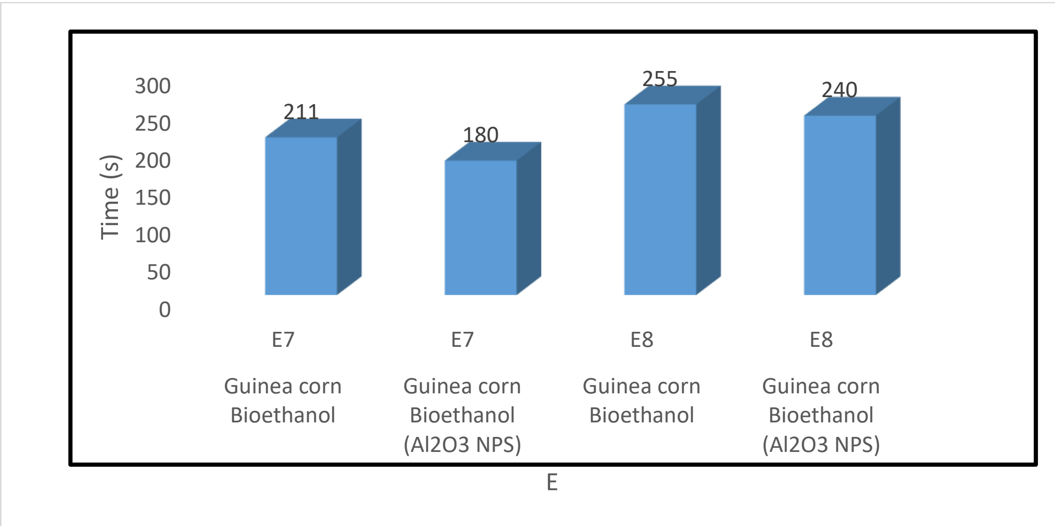

Figure 8: Comparison of the performance of the guinea corn produced bioethanol (without nanoparticles) mixed with conventional gasoline with guinea corn bioethanol produced with Aluminium oxide nanoparticles for E7 and E8.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The results obtained from the experimental tests that were conducted using the Sinwei electric power generating set showed that for the bioethanol produced from maize stalk that was mixed with conventional the E6 (94% gasoline mixed with 6% bioethanol) had the highest power output (40.86W) from the electric power generating set as measured by the digital multimeter. The performance analysis showed that the E5 (95% conventional gasoline mixed with 5% Bioethanol produced from maize stalk) had the highest running time of 260 seconds in the electric power generating set. E5 (95% conventional gasoline mixed with 5% bioethanol produced from guinea corn stalk had the highest power output (41.22W) of all the ratios of guinea corn produced bioethanol that was tested. Results for the bioethanol that was produced from guinea corn also revealed that E8 (92% conventional gasoline mixed 8% bioethanol) had the highest running time of 240 seconds in the Sinwei electric power generating set. Other samples returned a shorter time for the same experiment. Overall, the bioethanol that was produced from maize stalk had the better performance when compared with the bioethanol that was produced from guinea corn stalk. The guinea corn bioethanol had the least desirable physicochemical properties, power output and overall performance in the Sinwei electric power generating set.

4.2 **Recommendations**

Further studies should be conducted on the use of nanoparticles to produce and synthesize bioethanol from maize stalks. In addition to the application of Aluminium oxide nanoparticles for the catalysis of bioethanol yield, other nanoparticles should be tested to determine better alternatives. Bioethanol produced from maize was found to have good physicochemical properties that were suitable as fuel mixture for combustion. Further studies should be conducted on better production processes and methods for bioethanol from maize stalks at cheaper rates with higher yields.

Bioethanol could serve as an alternative to compressed natural gas (CNG) for powering motor vehicles in Nigeria. Bioethanol are less volatile and more manageable in comparison with CNG which have proven to be a disaster thus far in Nigeria due to many incidence of explosions. A country like Brazil is a shining example of how funds could be conserved through the adoption of biofuels such as bioethanol. Most of the bioethanol produced in Brazil are produced from sugarcane molasses. Analysis of exhaust fumes should be conducted on all mixtures of bioethanol and gasoline for both maize and guinea corn at all compositions to determine the "eco-friendliness" of the produced biofuel with implications for climate change and the ozone layer protection. It is recommended that optimization analysis be conducted for the bioethanol produced from maize stalk with the most promising parameters and characteristics with consideration for yield, catalytic action, physicochemical properties and performance in IC engines.

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