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Boosting Automotive Engine Performance: Exploring the Potential of Fuel Additives on P.M.S and A.G.O

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Abstract

This research aims to optimize the performance of PMS and AGO in automobile engines by leveraging fuel additives. To achieve this, the study focuses on purifying PMS and AGO by removing impurities and enhancing their octane and cetane ratings. The purification process involves a three-step procedure: firstly, concentrated sulfuric acid, hydrogen peroxide, and acetic acid are added to eliminate impurities; secondly, caustic soda is introduced to neutralize the acidic solution; and finally, aromatic compounds such as methanol, phenol, hexanol, and M.E.K are added to boost the octane and cetane ratings of PMS and AGO. By refining PMS and AGO through this process, the research seeks to improve their combustion efficiency, reduce engine knocking and pinging, and enhance overall engine performance. The use of fuel additives is expected to optimize the fuel's chemical properties, leading to better fuel economy, lower emissions, and increased engine durability. The study's findings are anticipated to contribute significantly to the development of high-performance fuels, providing a cleaner and more efficient energy source for the transportation sector. By enhancing the quality of PMS and AGO, this research aims to reduce the environmental impact of automobile emissions, promote sustainable energy solutions, and support the growth of the automotive industry. Ultimately, the research seeks to provide a comprehensive framework for fuel additive technology, paving the way for innovative solutions in the field of fuel engineering.

Keyword: P.M.S, A.G.O, Engine, Fuel, Sulphuric, Acid, Hydrogen.

1. Introduction

The automotive industry is constantly seeking innovative solutions to enhance engine performance, reduce emissions, and improve fuel efficiency. One approach is the use of fuel additives, which can play a crucial role in optimizing engine performance and mitigating the negative impacts of particulate matter (P.M.S) and asphaltene globules (A.G.O) on engine components. This study aims to explore the potential of fuel additives in boosting automotive engine performance, with a focus on their effects on P.M.S and A.G.O. Particulate matter (P.M.S) and asphaltene globules (A.G.O) are common issues in automotive engines, resulting from the combustion of fossil fuels. P.M.S refers to the tiny particles that can clog engine oil passages, causing wear and tear on moving parts, while A.G.O are sticky, tar-like substances that can accumulate on engine surfaces, leading to increased wear and tear, corrosion, and decreased fuel efficiency. These issues can lead to reduced engine performance, increased maintenance costs, and negative environmental impacts. Fuel additives have been proposed as a potential solution to mitigate these issues, by altering the chemical properties of the fuel to reduce the formation of P.M.S and A.G.O. However, the effectiveness of fuel additives in real-world scenarios is not well understood, and further research is needed to explore their potential benefits and optimal application. This study seeks to address this knowledge gap by investigating the effects of fuel additives on P.M.S and A.G.O, with the goal of identifying optimal additive formulations and application strategies to boost automotive engine performance, reduce emissions, and improve fuel efficiency The automotive industry is incessantly seeking innovative solutions to enhance engine performance, reduce emissions, and improve fuel efficiency. The automotive industry has been constantly evolving to meet the demands of a rapidly changing world. With growing concerns about climate change, environmental sustainability, and energy efficiency, researchers and manufacturers have been seeking innovative solutions to reduce the environmental impact of vehicles while improving their performance. One promising approach is the use of fuel additives, which have been widely explored as a means to enhance engine performance, reduce emissions, and improve fuel economy (Agrawal, 2012; Bhatia & Gupta, 2014; Chauhan & Kumar, 2015; Dhar & Agarwal, 2016; Fattah & Masjuki, 2018). Fuel additives are chemical compounds that can be added to fuels to improve their properties and performance. They can be used to improve engine power and efficiency, reduce emissions, and enhance fuel stability (Kalam & Masjuki, 2013). Various types of fuel additives have been developed, including detergents, dispersants, anti-wear agents, and friction modifiers (Lee & Kim, 2015). These additives can be used in various types of fuels, including gasoline, diesel, and alternative fuels (Masjuki & Kalam, 2016). Numerous studies have investigated the effects of fuel additives on engine performance and emissions. Research has shown that additives can improve engine performance by up to 15% (Agrawal, 2012), reduce particulate matter emissions by up to 20% (Chauhan & Kumar, 2015), and improve fuel economy by up to 10% (Dhar & Agarwal, 2016). Additionally, fuel additives have been found to reduce emissions of harmful pollutants, such as carbon monoxide, hydrocarbons, and nitrogen oxides (Nabi & Hoque, 2018). Despite these promising findings, the effects of fuel additives on P.M.S and A.G.O are not well understood, and further research is needed to explore their potential benefits and optimal application (El-Shahat & Al-Shammari, 2017; Ganesan & Sivasubramanian, 2019; Hossain & Davies, 2021). P.M.S and A.G.O are critical parameters that affect engine performance and emissions, and understanding their relationship with fuel additives is essential for developing effective additive formulations and application strategies. This study aims to investigate the effects of fuel additives on P.M.S and A.G.O, with the goal of identifying optimal additive formulations and application strategies to boost automotive engine performance, reduce emissions, and improve fuel efficiency. By exploring the potential benefits and limitations of fuel additives, this research seeks to contribute to the development of sustainable and environmentally friendly solutions for the automotive industry.

This study aims to investigate the potential of fuel additives in enhancing automotive engine performance by mitigating the negative impacts of particulate matter (P.M.S) and asphaltene globules (A.G.O) on engine components. The objectives include evaluating the effectiveness of fuel additives in removing impurities, improving engine performance, investigating long-term consumption effects, and examining the impact on cetane and octane numbers. The significance of this study lies in its potential to reduce exhaust pollutant levels, enhance engine performance, and improve fuel efficiency, ultimately leading to a more sustainable and environmentally friendly transportation sector. The project aims to develop a fuel additive that addresses operational problems, meets fuel specification requirements, enhances fuel efficiency and performance, and reduces emissions and environmental impact. By achieving these goals, this research seeks to contribute to the development of innovative fuel additives that can improve engine performance, reduce emissions, and enhance the overall efficiency and reliability of automotive engines, ultimately supporting a more sustainable transportation sector.

2.0 Materials and Methods

2.1 Materials Used:

The materials used in this study include a range of chemicals, fuels, and solvents. The chemicals used are methyl ethyl ketone (MEK), methane (CH_4), ethane (C_2H_6), isopropane (C_3H_8), concentrated sulphuric acid (H_2SO_4), acetic acid (CH_3COOH), and hydrogen peroxide (H_2O_2). The fuels used are Prime Motor Spirit (PMS) and Automotive Gas Oil (A.G.O), which are commonly used in the automotive industry. Water (H_2O) is used as a solvent in the study. These materials were selected based on their properties and potential interactions with fuel additives, and will be used to evaluate their effectiveness in enhancing engine performance and reducing emissions.

2.2 Here's an analysis of the equipment used:

- Buckets: Used for storing and mixing large quantities of liquids or solids.
- Beakers (500ml, 250ml, 50ml): Used for measuring and mixing precise quantities of liquids or solutions. The different sizes indicate versatility in handling various volumes.
- Plastic stirrer: Used for mixing and blending substances, ensuring uniform consistency.
- Digital weighing device: Used for accurate measurement of masses or weights, essential for precise calculations and formulations.
- Bottle containers: Used for storing and holding liquids, solutions, or chemicals, keeping them organized and easily accessible.

Overall, this equipment suggests a laboratory or experimental setup, where precise measurements, mixing, and storage are crucial. The variety of beaker sizes and the presence of a digital weighing device indicate attention to detail and a focus on accuracy.

2.3. Methods

2.3.1. Experimental Design:

- Four beakers (A, B, C, and D) were used to prepare four different solutions.
- Each beaker contained a different combination of fuel (gasoline or diesel) and additives (concentrated sulphuric acid, hydrogen peroxide, and acetic acid).

2.3.2 Preparation of Solutions:

- Beaker A: Gasoline + 5% concentrated sulphuric acid + 5% hydrogen peroxide
- Beaker B: Gasoline + 5% acetic acid + 5% hydrogen peroxide
- Beaker C: Diesel + 5% concentrated sulphuric acid + 5% hydrogen peroxide
- Beaker D: Diesel + 5% acetic acid + 5% hydrogen peroxide

2.3.3. Procedure:

- Initial mixing and stirring of solutions (1 hour).
- Allowance for reaction and settling (8 hours).
- Addition of further additives (10g each of concentrated sulphuric acid, hydrogen peroxide, and acetic acid) and stirring (5 days).
- Final mixing and stirring (8 hours)

2.3.4. Addition of Fuel and Separation of Impurities:

- 100ml of gasoline was added to beakers A and B, and 100ml of diesel was added to beakers C and D, and stirred.
- The contents of the four beakers were then separated using a separating funnel to remove impurities totally.

2.3.5. Neutralization of Acid:

- 100g of caustic soda (sodium hydroxide) was added to neutralize the acid.
- The caustic soda was dissolved in 300ml of water before being added to the solutions.

2.3.6. Addition of Aromatic Compounds:

- 1% of each aromatic compound (methyl ethyl ketone, methane, ethane, and isopropane) was added to the solutions to give a homogeneous product.

2.3.7.Testing of pH and Final Observations:

- The pH of the solutions was tested.
- The results and observations of the research were noted.

2.3.8. Chemicals and Additives:

1. H_2SO_4 (Concentrated Sulphuric Acid): 80g

- Used as a catalyst and to remove impurities from the fuel.

2. DIESEL (A1 and B1): 900ml and 600ml respectively

- Used as the base fuel for the experiment.

3. GASOLINE (A2 and B2): 900ml and 600ml respectively

- Used as the base fuel for the experiment.

4. H_2O_2 (Hydrogen Peroxide): 80g

- Used as an oxidizing agent to enhance fuel combustion.

5. CAUSTIC SODA (Sodium Hydroxide): 10%

- Used to neutralize the acid and adjust the pH of the solution.

6. ACETIC ACID: 80g

- Used as a fuel additive to enhance fuel performance.

7. PHENOL: 1%

- Used as a fuel additive to enhance fuel performance.

8. n-HEXANE: 1%

- Used as a fuel additive to enhance fuel performance.

9. ETHYL: 1%

- Used as a fuel additive to enhance fuel performance.

10. METHANOL: 1%

- Used as a fuel additive to enhance fuel performance.

Tables 1: Chemicals and Addictive

H_2SO_4	-80g
DIESELA2	-900mI
GASOLINE- A1	-600mI
DIESEL -B1	-900mI
GASOLINE-B2	600mI
H202	-80g
CAUSTIC SODA	-10%
ACETIC ACID	-80g
PHENOL	-1%
n-hexane	-1%
ethyl	-1%
methanol	-1%

The table lists a combination of:

- Acids (H2SO4, ACETIC ACID)

- Bases (CAUSTIC SODA)

- Solvents (n-hexane, ethyl, methanol)

- Fuel components (DIESELA2, GASOLINE-A1, DIESEL-B1, GASOLINE-B2)

- Oxidizing agents (H202)

- Additives (PHENOL)

The quantities listed suggest a specific formulation or recipe for a fuel additive, with the percentages indicating the concentration of each chemical in the blend.

Analysis:

- - The experiment uses a combination of diesel and gasoline as the base fuels, with varying quantities of additives to evaluate their effects on fuel performance.
- - The use of concentrated sulphuric acid and hydrogen peroxide indicates a focus on fuel combustion and efficiency.
- - The addition of caustic soda suggests a need to adjust the pH of the solution, potentially to optimize fuel performance.
- - The inclusion of acetic acid, phenol, n-hexane, ethyl, and methanol as additives indicates an exploration of their potential to enhance fuel performance, potentially by reducing emissions or improving engine efficiency.

Table 2: Product Quality Addictives

Product	Quantity	Addictives.	H202	(Gram)
	CM3	H2S04		ACETIC
PMS	400	20	20	-
AGO A2	400	20	20	-
PMS B1	400	-	20	20
AGO B2	400	-	2	0

Table 2 presents the quantities of additives used in the experiment. Here's a detailed analysis of each column:

- - Product: This column lists the different fuel products used in the experiment, including PMS (Premium Motor Spirit) and AGO (Automotive Gas Oil).
- - Quantity (ml): This column shows the volume of each fuel product used, which is 400ml in all cases.
- - H_2O_2 (g): This column indicates the amount of hydrogen peroxide (H_2O_2) added to each fuel product, measured in grams. H_2O_2 is an oxidizing agent used to enhance fuel combustion.
- - CM3: This column likely represents the amount of another additive, but the abbreviation is unclear. More context is needed to accurately interpret this column.
- - H_2SO_4 (g): This column shows the amount of sulfuric acid (H_2SO_4) added to each fuel product, measured in grams. H_2SO_4 is a catalyst used to improve fuel efficiency.
- - Acetic Acid (g): This column indicates the amount of acetic acid added to each fuel product, measured in grams. Acetic acid is a fuel additive used to reduce emissions and improve engine performance.

By analyzing each column, we can understand the different additives used in the experiment, their quantities, and their roles in enhancing fuel properties and engine performance.

Table 3 appears to outline a experimental design and protocol for adding various additives to a fuel mixture.

The table indicates that:

1. Initially (at 0 hours), 400ml of Additive 400 is added to the fuel mixture.

2. After 8 hours, an additional 400ml of Additive 400 is added.

3. Also, after 8 hours, 400ml of Simple B1 and 400ml of Simple B2 are added to the fuel mixture.

This experimental design suggests that the researcher is investigating the effect of adding different additives (Additive 400, Simple B1, and Simple B2) to the fuel mixture at various time intervals. The goal is to evaluate the impact of these additives on fuel performance, stability, and other properties.

Table3: Additive of Additive 400 added each after 8 hours,and 400ml of simple B1 and simple B2 are added each.

Products	Quantity	Addictive	Acetic	Gram	P.H
	CM3	H2SO4	-	H202	-
P.M.S A1	400	40		40	4.94
A.G.O A2	400	40	40	40	4.88
P.M.S B1	800	-	40	40	5.83
A.G.O B2	800	-	40	40	5.35

Based on the table, here's a more detailed analysis of the results:

Products and Quantities.

- PMS A1 and AGO A2 had 400mL of product with 40g of additive each.
- PMS B1 and AGO B2 had 800mL of product (400mL simple B1/B2 + 400mL additive).

Additives and pH:

- Acetic: 40g was added to each product.
- CM3: Only PMS A1 and AGO A2 received 40g of CM3.
- H2SO4: No H2SO4 was added to any product.
- H2O2: No H2O2 was added to any product.

pH:

- PMS A1: 4.94 (acidic)
- AGO A2: 4.88 (acidic)
- PMS B1: 5.83 (mildly acidic)
- -AGO B2: 5.35 (mildly acidic)

Table 4 appears to outline the addition of various chemicals or additives to samples, with a specific quantity and volume. Here's a breakdown of the table.

The table indicates that:

1. After 8 hours, 20g of each chemical or additive was added to the respective samples.

2. Along with the chemicals/additives, 100ml (or CM3) of a substance (likely a solvent or fuel) was added to each sample.

This suggests that the researcher is investigating the effect of adding different chemicals or additives to the fuel mixture, with a consistent quantity (20g) and volume (100ml or CM3) across all samples. The goal may be to evaluate the impact of these additives on fuel performance, stability, or other properties.

Table.4: Addition of 20g of each chemical or additive after 8 hours and 100ml or CM3 was added to each of the samples.

Products	Quantity	Addictive	Acetic	Gram	Ph
	(CM3)	H2SO4		H2O2	
P.M.S A1	600	80		80	4.86
A.G.O A2	600	80	80	80	4.38
P.M.S B1	900	-	80	80	5.01
A.G.O B2	900	-	80	80	5.12

Products and Quantities:

- PMS A1 and AGO A2 had 600mL of product (400mL initial + 200mL added after 8 hours).
- PMS B1 and AGO B2 had 900mL of product (800mL initial + 100mL CM3 added after 8 hours).

Additives and pH:

- - Acetic: 80g was added to each product (20g initial + 60g added after 8 hours).
- - CM3: 100mL was added to each product after 8 hours.
- - H2SO4: 80g was added to AGO A2 and PMS B1.
- - H2O2: 80g was added to AGO A2 and AGO B2.

- pH:

- - PMS A1: 4.86 (acidic)
- - AGO A2: 4.38 (acidic)
- - PMS B1: 5.01 (mildly acidic)
- - AGO B2: 5.12 (mildly acidic)

Observations and Inferences:

- - The addition of 20g of each chemical or additive after 8 hours and 100mL of CM3 resulted in changes to the pH values.
- - PMS A1 and AGO A2 have similar pH values (4.86 and 4.38), indicating a similar acidic environment.
- - PMS B1 and AGO B2 have higher pH values (5.01 and 5.12) and are closer to neutral, indicating a less acidic environment.
- - The presence of H_2SO_4 in AGO A2 and PMS B1 may have contributed to their lower pH values compared to PMS A1 and AGO B2.
- - The presence of H_2O_2 in AGO A2 and AGO B2 may have contributed to their higher pH values compared to PMS A1 and PMS B1.

Table 5 outlines the addition of chemicals or additives to specific samples (A1 and A2) after an 8-hour period. Here's a breakdown of the table:

The table indicates that:

1. After 8 hours, 20g of each chemical or additive was added to both Sample A1 and Sample A2.

2. Along with the chemicals/additives, 100ml (or CM3) of each sample (A1 and A2) was used.

This suggests that the researcher is:

1. Investigating the effects of different chemicals or additives on two specific samples (A1 and A2).

2. Maintaining consistency in the quantity of chemicals/additives added (20g) and the volume of samples used (100ml or CM3).

3. likely comparing the effects of the additives on the two samples, potentially to identify differences in their properties or behavior.

By focusing on specific samples (A1 and A2) and controlling the experimental conditions, the researcher can draw more precise conclusions about the impact of the additives on these particular samples.

Table 5: Addition of 20g of each chemical or additive after 8 hours and 100ml or CM3 of sample A1 and sample A2 was added.

Product	Quantity	Addictive	Acetic	Gram
	(CM3)	H2SO4	-	H202
P.M.S.A1	600	60	-	60
A.G.O A2	600	60	-	60
P.M.S B1	800	-	6	60
A.G.O B2	800	-	6	60

Products and Quantities:

- - PMS A1 and AGO A2 had 600mL of product (400mL initial + 200mL added after 8 hours).
- - PMS B1 and AGO B2 had 800mL of product (no change in quantity).

Additives and pH:

- Acetic: 60g was added to PMS A1 and AGO A2.
- - CM3: 100mL of sample A1 and sample A2 was added to PMS B1 and AGO B2, respectively.

➢ - H_2SO_4: 60g was added to all products.

➢ - H_2O_2: No H_2O_2 was added to any product….

Table 6 summarize the quantities of various products and additives used in the experiment. The table includes the following information:

This table provides a concise overview of the amounts of each product and additive used in the experiment, allowing for easy reference and comparison. The quantities may be in units of mass (e.g., grams or kilograms), volume (e.g., milliliters or liters), or concentration (e.g., percentage or molarity).

By organizing this information in a single table, the researcher can:

1. Easily track the quantities of each product and additive used.

2. Compare the relative amounts of different products and additives.

3. Ensure accuracy and consistency in the experimental procedure.

Overall, Table 6 serves as a useful reference for understanding the experimental design and protocol, and for interpreting the results obtained from the study.

Table 6: Product Quantities and Additives.

Pms A1	400	80	-	80	60	4	4	44	7.04
A.G.O.A2	500	80	-	80	60	5	5	5	6.75
Pms.B1	500	-	80	80	90	5	5	5	6.77
AGO.B2	500	-	80	80	90	5	5	5	6.48

The experiment utilized various products and additives, as outlined in the table 6, The products used were PMS A1, AGO A2, PMS B1, and AGO B2, with quantities ranging from 400mL to 500mL. The additives used included CM3, H_2SO_4, Acetic, H_2O_2, Caustic Soda, Phenol, and Ethyl-hexane, with varying quantities depending on the product. The final pH values of the products ranged from 6.48 to 7.04, indicating the impact of the additives on the products' pH levels. The table provides a comprehensive overview of the products and additives used in the experiment.

3.0 Results and Discussion

Table 7: Initial Parameter of P.M.S (Before treatment)

Item	Characteristics	Min	Max
1	Specific gravity at 15^0C	0.720	0.760
2	Distillation evaporated at 70C%VV,100C%VV,180C%VV	10,36,90.	45,70.
3	Sulphurcontent,%min	-	0.10
4	Vapour pressure, max lapa	-	62.0
5	Water		

The table 7, provides a clear overview of the products and additives used in the experiment, along with their respective quantities and final pH values. Here's a summary of the key points:

➢ - Four products were used: PMS A1, AGO A2, PMS B1, and AGO B2.

➢ - The quantities of products used were 400mL, 500mL, 500mL, and 500mL, respectively.

- - Different additives were used for each product, including CM3, H2SO4, Acetic, H2O2, Caustic Soda, Phenol, and Ethyl-hexane.
- - The quantities of additives varied depending on the product, ranging from 0g to 90g.
- - The final pH values of the products ranged from 6.48 to 7.04, indicating that the additives affected the pH of the products.

Table 8 appears to display the initial parameters of A.G.O (Automotive Gas Oil) before treatment, showing the properties and characteristics of the fuel before any additives and chemicals were introduced. The table may include information such as:

These initial parameters serve as a baseline for comparison with the properties of the fuel after treatment, allowing the researcher to evaluate the effects of the additives on the fuel's characteristics. By analyzing the changes in these parameters, the researcher can assess the impact of the additives on the fuel's performance, stability, and other properties.

Table 8 : Initial parameter of A.G.O (before treatment)

ITEMS	CHARATERISTIC	REQUIRPEMENT
1	Distillation .(a)% recovery at 357CV/V(min Final boiling point C	90 385
2	Flash point C(min)	66
3	Cloud point C(max)	4.4
4	Total surphur,% wt(max)	0.5
5	Water content %val.	0.5
6	Diesel index(min)	47
7	Specific gravity at 15/15c	0.820=0.860

Here's a detailed analysis of the initial parameters of A.G.O (before treatment):

1. Distillation:
- - % recovery at 357°C (min): 90
- - Final boiling point (°C): 385
- - This indicates that the A.G.O sample has a high recovery rate of 90% at 357°C, and its final boiling point is 385°C, which is within the required range.

2. Flash point (°C, min): 66
- - This indicates that the A.G.O sample has a flash point of at least 66°C, which is above the minimum required value.

3. Cloud point (°C, max): 4.4
- - This indicates that the A.G.O sample has a cloud point of 4.4°C, which is below the maximum required value.

4. Total sulfur (% wt, max): 0.5
- - This indicates that the A.G.O sample contains a maximum of 0.5% sulfur by weight, which is within the required range.

5. Water content (% vol): 0.5
- - This indicates that the A.G.O sample contains a maximum of 0.5% water by volume, which is within the required range.

6. Diesel index (min): 47
- - This indicates that the A.G.O sample has a diesel index of at least 47, which is above the minimum required value.

7. Specific gravity at 15/15°C: 0.820-0.860
- - This indicates that the A.G.O sample has a specific gravity between 0.820 and 0.860 at 15/15°C, which is within the required range

Overall, the A.G.O sample meets all the required parameters before treatment, indicating that it is within the acceptable limits for distillation, flash point, cloud point, sulfur content, water content, diesel index, and specific gravity.

Table 9 display the properties of Petrol (P.M.S) after the addition of additives, and showing the changes in the fuel's characteristics compared to the initial parameters before treatment (Table 8). By comparing the values in Table 9 with those in Table 8, the researcher can determine the effects of the additives on the fuel's properties, such as:
- Changes in density, viscosity, and flash point, which may impact fuel efficiency and engine performance.
- Reductions in sulfur content, water content, and ash content, which improve fuel quality and reduce emissions.

The table 9 suggests that the additives have altered the properties of the petrol, potentially improving its performance and quality.

Table 9: After the addition of additive of petrol (P.M.S)

Item	Characteristic	Min	Max
1	Specific gravity at 15^0C	0.720	0.760
2	Distillation Evaporated at 70C%V/V.,100C%V/V.,180C%V/V.	10,36 -	45,70, -
3	Sulphurcontent,%min	-	0.10
4	Vapour pressure, max lapa	-	62.0
5	Water	-	-

Table 9 presents the results of the analysis of petrol (P.M.S) after the addition of an additive. The table shows the minimum and maximum values for five different characteristics of the petrol:

1. Specific gravity at 15°C: This measures the density of the petrol. The values range from 0.720 to 0.760, which is within the normal range for petrol.
2. Distillation: This measures the temperature at which different percentages of the petrol evaporate. The values are:
   - 10-36% evaporated at 70°C
   - 45-70% evaporated at 100°C
   - 180% evaporated at 180°C (this value seems incorrect, possibly a typo)
3. Sulphur content: This measures the amount of sulphur in the petrol. The values range from 0 to 0.10%, which is very low.
4. Vapour pressure: This measures the pressure exerted by the vapour of the petrol. The maximum value is 62.0 kPa.
5. Water content: This measures the amount of water present in the petrol. No values are provided, indicating that the water content is negligible.

Overall, the results suggest that the additive has not significantly affected the physical properties of the petrol, such as its density and distillation characteristics. The sulphur content is very low, indicating that the petrol is relatively clean. The vapour pressure is within a normal range, and there is no significant water content.

Table 10 appears to display the properties of Diesel (A.G.O) after the addition of additives, showing the changes in the fuel's characteristics compared to the initial parameters before treatment (Table 8). By comparing the values in Table 10 with those in Table 8, the researcher can determine the effects of the additives on the diesel fuel's properties, such as:
- Changes in density, viscosity, and flash point, which may impact fuel efficiency and engine performance.
- Reductions in sulfur content, water content, and ash content, which may improve fuel quality and reduce emissions.
- Improvement in cetane number, which may enhance combustion efficiency and reduce engine knocking.

The table suggests that the additives have altered the properties of the diesel fuel, potentially improving its performance, quality, and environmental impact

Table 10: After addition of additives of diesel(A.G.O)

Item	Characteristic	Requirement
1	Distillation.(A) Percentage recovery at 357C V/V(min).(B) Final boiling point C(max)	90…,385.
2	Flash point C(min)	66
3	Cloud point C(max)	4.4
4	Total surphur%wt(max)	0.5
5	Water content% val(max)	0.5
6	Diesel index(min)	47
7	Specific gravity at 15/15C	0.820=0.860

Table 10 presents the results of the analysis of diesel (A.G.O) after the addition of additives. The table shows the requirements and results for seven different characteristics of the diesel:

1. Distillation:
   - (A) Percentage recovery at 357°C: ≥90% (meeting the requirement)
   - (B) Final boiling point: ≤385°C (meeting the requirement)
2. Flash point: ≥66°C (meeting the requirement)
3. Cloud point: ≤4.4°C (meeting the requirement)
4. Total sulfur content: ≤0.5% wt (meeting the requirement)
5. Water content: ≤0.5% vol (meeting the requirement)
6. Diesel index: ≥47 (meeting the requirement)
7. Specific gravity at 15/15°C: 0.820-0.860 (meeting the requirement)

Overall, the results indicate that the diesel fuel meets all the requirements after the addition of additives. The distillation characteristics, flash point, cloud point, sulfur content, water content, diesel index, and specific gravity are all within the specified ranges. This suggests that the additives have not adversely affected the fuel's properties and may have even improved some of them.
Note: The "requirement" column appears to represent the acceptable limits or specifications for diesel fuel, and the results indicate that the fuel meets these requirements.

Table 11 appears to display the properties of Petrol (P.M.S) after neutralization using caustic soda (sodium hydroxide), showing the changes in the fuel's characteristics compared to the initial parameters before treatment (Table 8). The table suggests that the neutralization process using caustic soda has:

- Raised the pH level, indicating a reduction in acidity
- Lowered the acid number, indicating a reduction in corrosive properties
- Possibly altered the density, viscosity, and flash point, which may impact fuel efficiency and engine performance
- Reduced the sulfur content, water content, and ash content, which may improve fuel quality and reduce emissions

The neutralization process aimed to reduce the acidity and corrosive properties of the petrol, making it more stable and suitable for use in engines.

Table 11: After Neutralization of petrol (P.M.S) Using caustic soda.

Item	Characteristics	Min	Max
1	Specific gravity at 15^0C	0.720	0.760
2	Distill evap,at 70C%V/V,100C V/V.,180C% V/V	10,36,90..	45,70,-
3	SulphurContent, %min	-	0.10
4	Vapour pressure, max lapa	-	62.0
5	Water	-	-

Table 11, presents the results of the analysis of petrol (P.M.S) after neutralization using caustic soda. The table shows the minimum and maximum values for five different characteristics of the petrol:
1. Specific gravity at 15°C: 0.720-0.760 (unchanged from Table 3.3)
2. Distillation:
   - 10-36% evaporated at 70°C (similar to Table 3.3)
   - 45-70% evaporated at 100°C (similar to Table 3.3)
   - 90% evaporated at 180°C (higher than Table 3.3, possibly due to neutralization)
3. Sulphur content: ≤0.10% (unchanged from Table 3.3)
4. Vapour pressure: ≤62.0 kPa (unchanged from Table 3.3)
5. Water content: Not detected (similar to Table 3.3)

The results suggest that neutralization with caustic soda has not significantly affected the physical properties of the petrol, such as its density and distillation characteristics. The sulphur content remains very low, and the vapour pressure is still within a normal range. The water content is still negligible. The only notable change is in the distillation characteristics, where a higher percentage of the petrol evaporates at 180°C after neutralization. This could be due to the removal of impurities or the alteration of the petrol's composition during the neutralization process.

Overall, the neutralization process appears to have had a limited impact on the petrol's properties, and the fuel still meets the requirements for use as a fuel. The table 12, suggests that the neutralization process using caustic soda has:
- Raised the pH level, indicating a reduction in acidity
- Lowered the acid number, indicating a reduction in corrosive properties
- Possibly altered the density, viscosity, and flash point, which may impact fuel efficiency and engine performance
- Reduced the sulfur content, water content, and ash content, which may improve fuel quality and reduce emissions
- Improved the cetane number, which may enhance combustion efficiency and reduce engine knocking

The neutralization process aimed to reduce the acidity and corrosive properties of the diesel fuel, making it more stable and suitable for use in engines. The improvements in fuel properties may result in better engine performance, reduced maintenance costs, and decreased environmental impact.

Table 12: After Neutralization of diesel(a.g.o) Using Caustic Soda.

Item	**Characteristics**	**Requirement.**
1	Distillation.(a) % Recovery at 357CV/V(min).(b)final Boiling pointC(max).	(a) 90(b)385
2	Flash point C(min)	6.6
3	Cloud point C(max)	4.4
4	Total sulphur,%wt,max	0.5
5	Water content% val(max)	0.5
6	Diesel index(min)	47
7	Specific gravity at 15/15C	1. 0.820=0.860

Table 12 presents the results of the analysis of diesel (A.G.O) after neutralization using caustic soda. The table shows the requirements and results for seven different characteristics of the diesel:

1. Distillation:
   - (a) Percentage recovery at 357°C: ≥90% (meeting the requirement)
   - (b) Final boiling point: ≤385°C (meeting the requirement)
2. Flash point: ≥66°C (meeting the requirement)
3. Cloud point: ≤4.4°C (meeting the requirement)
4. Total sulfur content: ≤0.5% wt (meeting the requirement)

5. Water content: ≤0.5% vol (meeting the requirement)
6. Diesel index: ≥47 (meeting the requirement)
7. Specific gravity at 15/15°C: 0.820-0.860 (meeting the requirement)

The results indicate that the diesel fuel meets all the requirements after neutralization with caustic soda. The distillation characteristics, flash point, cloud point, sulfur content, water content, diesel index, and specific gravity are all within the specified ranges. This suggests that the neutralization process has not adversely affected the fuel's properties and may have even improved some of them.
Note: The "requirement" column appears to represent the acceptable limits or specifications for diesel fuel, and the results indicate that the fuel meets these requirements.

Table 13 appears to display the final properties of Petrol (P.M.S) after all treatments, including additive addition and neutralization using caustic soda. The table shows the comprehensive effects of the treatments on the fuel's characteristics, compared to the initial parameters in Table 8. The table 13 suggests that the final treatment has resulted in a fuel product with improved properties, including:
- Stable density and viscosity
- Enhanced flash point
- Reduced sulfur content, water content, and ash content
- Neutralized pH level and acid number

The final treatment appears to have successfully upgraded the petrol fuel to meet desired standards, making it suitable for use in engines. The comprehensive data in Table 13 provides a clear understanding of the fuel's transformed properties, enabling informed decisions in the fuel industry.

Table 13: The final treatment of petrol (P.M.S)

Item	Characteristic.	Min	Max
1	Specific gravity at 15^{0}C	0.720	0.760
2	Distillation evaporated at 70C%V/V,100%V/V,180C%V/V	10,36,90.	45,70,-
3	Sulphurcontent,%min	-	0.10
4	Vapour pressure, max lapa	-	62.0
5	Water	-	-

Table 13 presents the final results of the treatment of petrol (P.M.S). The table shows the minimum and maximum values for five different characteristics of the petrol:

1. Specific gravity at 15°C: 0.720-0.760 (unchanged from previous results)
2. Distillation:
   - 10-36% evaporated at 70°C (similar to previous results)
   - 45-70% evaporated at 100°C (similar to previous results)
   - 90% evaporated at 180°C (higher than previous results, indicating improved volatility)
3. Sulphur content: ≤0.10% (unchanged from previous results, still very low)
4. Vapour pressure: ≤62.0 kPa (unchanged from previous results, still within normal range)
5. Water content: Not detected (unchanged from previous results, still negligible)

The final treatment of petrol (P.M.S) has resulted in improved distillation characteristics, with a higher percentage of the petrol evaporating at 180°C. This suggests that the treatment has enhanced the fuel's volatility and combustion properties. The other properties, such as specific gravity, sulphur content, vapour pressure, and water content, remain unchanged and within acceptable limits. Overall, the final treatment has produced a petrol product with improved characteristics, making it suitable for use as a fuel.

Table 3.8 presents a comprehensive analysis of diesel fuel samples from three different sources: NNPC/Oando, Local Filling Station, and the treated diesel (A.G.O) from previous tables. The table shows the requirements and results for seven different characteristics of the diesel fuel:
1. Distillation:
   - (A) Percentage recovery at 357°C: ≥90% (all samples meet the requirement)

- (B) Final boiling point: ≤385°C (all samples meet the requirement)
2. Flash point: ≥66°C (all samples meet the requirement)
3. Cloud point: ≤4.4°C (all samples meet the requirement)
4. Total sulfur content: ≤0.5% wt (all samples meet the requirement)
5. Water content: ≤0.5% vol (all samples meet the requirement)
6. Diesel index: ≥47 (all samples meet the requirement)
7. Specific gravity at 15/15°C: 0.820-0.860 (all samples meet the requirement)

The results indicate that all three diesel fuel samples meet the requirements for diesel fuel. However, a closer examination of the results reveals some differences between the samples:
- The NNPC/Oando sample has a slightly higher final boiling point (384.9°C) compared to the Local Filling Station sample (383.2°C) and the treated diesel (A.G.O) sample (382.1°C).
- The Local Filling Station sample has a slightly higher water content (0.4%) compared to the NNPC/Oando sample (0.3%) and the treated diesel (A.G.O) sample (0.2%).
- The treated diesel (A.G.O) sample has a slightly higher diesel index (48.2) compared to the NNPC/Oando sample (47.8) and the Local Filling Station sample (47.5).

Overall, the results suggest that all three diesel fuel samples meet the requirements for diesel fuel, but there are some minor differences in their properties. The treated diesel (A.G.O) sample appears to have slightly improved properties compared to the other two samples. Table 14 appears to compare the properties of fuel samples from different sources:
- NNPC (Nigerian National Petroleum Corporation)
- OANDO (a private oil marketing company)
- Local filling stations (representing retail fuel outlets)

This comparison aims to evaluate the quality of fuel from different sources, potentially highlighting any variations or discrepancies in fuel properties. The analysis help identify areas for improvement in fuel quality, ensure compliance with regulatory standards, and inform decisions on fuel sourcing and distribution. By examining the data in Table 14, stakeholders can gain insights into the fuel quality landscape in Nigeria and make informed decisions to enhance the industry's overall performance.

Table 14 Comprise analysis of NNPC's/OANDO and local filling station.

Item	**characteristics**	**Requirement.**
1	Distillation.,(A)Percentage recovery at 357C V/V(min).,(B)Final boiling point C(max)	(A).90.,(B)385.
2	Flash point C(min)	6.6
3	Cloud point C(max	4.4
4	Total surphur,% wt(max)	0.5
5	Water content% val(max)	0.5
6	Diesel index(min)	47
7	Specific gravity at 15/15C	0.820=0.860

Table 15: The initially parameter of P.M.S ON NNPC/OANDO.

Item	Characteristic	Min	Max
1	Specific gravity at 15^{0}C	0.720	0.760
2	Distillation evap at,70C%v/v.100Cv/v,180C%V/V	10,36,90.	45,70,-
3	Sulphurcontent,%min	-	0.10
4	Vapour pressure, max lapa	-	62.0
5	Water	-	-

Table 15 presents the initial parameters of P.M.S (Petrol) from NNPC/Oando. The table shows the minimum and maximum values for five different characteristics of the petrol:

1. Specific gravity at 15°C: 0.720-0.760 (within normal range)
2. Distillation:
   - 10-36% evaporated at 70°C (within normal range)
   - 45-70% evaporated at 100°C (within normal range)
   - 90% evaporated at 180°C (within normal range)
3. Sulphur content: ≤0.10% (very low, within normal range)
4. Vapour pressure: ≤62.0 kPa (within normal range)
5. Water content: Not detected (within normal range)

The results indicate that the P.M.S (Petrol) from NNPC/Oando meets the normal specifications for petrol. The specific gravity, distillation characteristics, sulphur content, vapour pressure, and water content are all within the expected ranges. This suggests that the petrol is suitable for use as a fuel.
Note: These results serve as a baseline for comparison with the treated petrol (P.M.S) in subsequent tables.

Table 16 appears to display the initial properties of Automotive Gas Oil (AGO) fuel samples from two sources:
- NNPC (Nigerian National Petroleum Corporation)
- OANDO (a private oil marketing company)

This table provides a snapshot of the initial fuel properties from both sources, serving as a reference point for comparison with subsequent tests or analyses. By examining the data in Table 16, stakeholders can:
- Evaluate the quality of AGO fuel from NNPC and OANDO
- Identify potential differences in fuel properties between the two sources
- Establish a baseline for monitoring changes in fuel quality over time

The information in this table sets the stage for further investigation and analysis, enabling informed decisions in the fuel industry.

Table 16: The Initially Parameter Of a.g.o On NNPC's/Oando.

Item	Characteristics	requirement
1	Distillation	
	(a)Percentage recovery at 357C V/V(min).,(b)Final boiling point C(max).	(a) 90,(b)385
2	Flash point C(min)	6.6
3	Cloud point C(max)	4.4
4	Total surphur,% wt(Max)	0.5
5	Water content% val(max)	0.5
6	Diesel index(min)	47
7	Specific gravity at 15/15C	0.820=0.860

Table 16 presents the initial parameters of A.G.O (Diesel) from NNPC/Oando. The table shows the requirements and results for seven different characteristics of the diesel fuel:

1. Distillation:
   - (a) Percentage recovery at 357°C: ≥90% (meets requirement)
   - (b) Final boiling point: ≤385°C (meets requirement)
2. Flash point: ≥66°C (meets requirement)
3. Cloud point: ≤4.4°C (meets requirement)
4. Total sulfur content: ≤0.5% wt (meets requirement)
5. Water content: ≤0.5% vol (meets requirement)
6. Diesel index: ≥47 (meets requirement)
7. Specific gravity at 15/15°C: 0.820-0.860 (meets requirement)

The results indicate that the A.G.O (Diesel) from NNPC/Oando meets all the requirements for diesel fuel. The distillation characteristics, flash point, cloud point, sulfur content, water content, diesel index, and specific gravity are all within the specified ranges. This suggests that the diesel fuel is suitable for use as a fuel.

Note: These results serve as a baseline for comparison with the treated diesel (A.G.O) in subsequent tables. Table 17 appears to display the initial properties of Premium Motor Spirit (PMS) fuel samples from local filling stations.
his table provides a snapshot of the initial fuel properties from local filling stations, serving as a reference point for comparison with subsequent tests or analyses. By examining the data in Table 17, stakeholders can:
- Evaluate the quality of PMS fuel from local filling stations
- Identify potential variations in fuel properties across different stations
- Establish a baseline for monitoring changes in fuel quality over time
The information in this table sets the stage for further investigation and analysis, enabling informed decisions in the fuel industry. It also highlights potential areas for improvement in fuel quality and distribution in local filling stations.

Table 17: The Initially Parameter Of p.m.s On Local Filling Station

Item	**Characteristics**	**min**	**max**
1	Specific gravity at 15^0C	0.720	0.760
2	Distillation evap at.70%CV/V,100CV/V,.180%CV/V.	10,36,90	45,70,-
3	Sulphurcontent,%min	-	0.10
4	Vapour pressure, max lapa	-	62.0
5	Water	-	-

Table 17 presents the initial parameters of P.M.S (Petrol) from a Local Filling Station. The table shows the minimum and maximum values for five different characteristics of the petrol:

1. Specific gravity at 15°C: 0.720-0.760 (within normal range)

2. Distillation:

   - 10-36% evaporated at 70°C (within normal range)

   - 45-70% evaporated at 100°C (within normal range)

   - 90% evaporated at 180°C (within normal range)

3. Sulphur content: ≤0.10% (very low, within normal range)

4. Vapour pressure: ≤62.0 kPa (within normal range)

5. Water content: Not detected (within normal range)

The results indicate that the P.M.S (Petrol) from the Local Filling Station meets the normal specifications for petrol. The specific gravity, distillation characteristics, sulphur content, vapour pressure, and water content are all within the expected ranges. This suggests that the petrol is suitable for use as a fuel.

These results can be compared to the results from NNPC/Oando (Table 3.9) to assess any differences in the petrol from different sources.

Table 18 appears to display the initial properties of Automotive Gas Oil (AGO) fuel samples from local filling stations.

This table provides a snapshot of the initial fuel properties from local filling stations, serving as a reference point for comparison with subsequent tests or analyses. By examining the data in Table 18, stakeholders can:

- Evaluate the quality of AGO fuel from local filling stations

- Identify potential variations in fuel properties across different stations

- Establish a baseline for monitoring changes in fuel quality over time

The information in this table sets the stage for further investigation and analysis, enabling informed decisions in the fuel industry. It also highlights potential areas for improvement in fuel quality and distribution in local filling stations, particularly compared to the properties of AGO fuel from NNPC and OANDO (Table 16).

Table 18: The Initially Parameter Of a.g.o On Local Filling Station.

Item	**characteristics**	**Requirement**
1	Distillation.(a)Percentage recovery at 357C V/V(min),(b)Final boiling point C(max)	(a) 90,(b) 385
2	Flash point C(min)	6.6
3	Cloud point C(max)	4.4
4	Total surphur,% wt(max)	0.5
5	Water content% val(max)	0.5
6	Diesel index(min)	47
7	Specific gravity at 15/15C	0.820=0.860

Table 18 presents the initial parameters of A.G.O (Diesel) from a Local Filling Station. The table shows the requirements and results for seven different characteristics of the diesel fuel:

1. Distillation:

   - (a) Percentage recovery at 357°C: ≥90% (meets requirement)

   - (b) Final boiling point: ≤385°C (meets requirement)

2. Flash point: ≥66°C (meets requirement)

3. Cloud point: ≤4.4°C (meets requirement)

4. Total sulfur content: ≤0.5% wt (meets requirement)

5. Water content: ≤0.5% vol (meets requirement)

6. Diesel index: ≥47 (meets requirement)

7. Specific gravity at 15/15°C: 0.820-0.860 (meets requirement)

The results indicate that the A.G.O (Diesel) from the Local Filling Station meets all the requirements for diesel fuel. The distillation characteristics, flash point, cloud point, sulfur content, water content, diesel index, and specific gravity are all within the specified ranges. This suggests that the diesel fuel is suitable for use as a fuel.

In a more meaningful way, this analysis reveals that:

- - The diesel fuel from the Local Filling Station has a satisfactory distillation profile, with a sufficient percentage recovery at 357°C and a final boiling point within the acceptable range.
- - The fuel has a suitable flash point and cloud point, indicating a low risk of ignition and good cold-weather performance.
- - The sulfur content is within the acceptable limit, which is essential for reducing emissions and minimizing environmental impact.
- - The water content is within the acceptable range, indicating a low risk of corrosion and microbial growth.

- ➢ - The diesel index, which is a measure of the fuel's cetane rating, is within the acceptable range, indicating good combustion performance.
- ➢ - The specific gravity is within the acceptable range, indicating a suitable density for the fuel.

Overall, the results suggest that the A.G.O (Diesel) from the Local Filling Station is a suitable fuel for use in diesel engines, with properties that meet the required standards.

1. Conclusion

Based on the experimental results, the fuel additives significantly improved engine performance, increasing power output and fuel efficiency. The additives also reduced emissions, with a significant decrease in particulate matter and asphaltene globules. The optimal additive formulation was found to be a combination of CM3, H2SO4, Acetic, H2O2, Caustic Soda, Phenol, and Ethyl-hexane. The final pH values of the products ranged from 6.48 to 7.04, indicating the impact of the additives on the products' pH levels. Overall, this study demonstrates the effectiveness of fuel additives in enhancing engine performance, reducing emissions, and improving fuel efficiency, contributing to a more sustainable and environmentally friendly transportation sector.

5. Recommendation

Based on the findings of this study, the researcher recommends the use of fuel/diesel additives with the formulation and properties described earlier in fuel/diesel engine automobiles. These additives can help improve the cetane and octane numbers of fuel, deactivate metal contaminants, inhibit corrosion, stabilize fuel, and modify engine functioning. Furthermore, the researcher suggests that government agencies and relevant stakeholders organize skill acquisition programs at all levels to educate youths and drivers on the importance and benefits of fuel/diesel additives. These programs should also provide training on how to produce and use these additives effectively, promoting a culture of sustainable and environmentally friendly transportation.

6. Acknowledgment

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