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Analysis of Premium Motor Spirit (PMS) Distributed in Lagos Metropolis, Nigeria

C. Ikeora Onyinye and H. Okoye Nkechi

Department of Pure and Industrial Chemistry; Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

Abstract: Premium motor spirit samples from three different oil depots in Lagos Metropolis were analyzed. Properties studied were the density test, octane number test, ethanol content test, distillation test, benzene content test and the sulphur content test. The results obtained are as follows: density test $0.7436 \pm 1.782\times10^{-3}$, research octane number test 92.3 ± 0.497, ethanol content was absent, distillation test at the initial boiling point 39 ± 0.817°C, at the final boiling point 204 ± 0.817°C, benzene content test 0.933 ± 0.386%, the sulphur content test $0.0344 \pm 2.271 \times 10^{-7}$%. Though the study suggests that the PMS quality was within ASTM Standards, it is imperative that regular quality tests be conducted randomly to check adulteration.

Key words: Premium Motor Spirit · Adulteration · Research Octane Number · Sulphur Content · Distillation Profile

INTRODUCTION

Premium Motor Spirit (PMS) popularly called petrol in this part of the world with boiling range 40-200°C(consists 5 to 12 carbon atoms) is a complex mixture of hydrocarbons produced by mixing fractions obtained from the distillation of crude oil with brand-specific additives to improve its performance. It is a major product from the fractional distillation of petroleum (also known as "Black Gold'' or "Crude Oil" which is a naturally occurring, yellow-to-black liquid found in geologic formations beneath the Earth's surface. Simply put, petroleum is a mixture of hydrocarbons that exists as a liquid in natural underground reservoirs and remains liquid when brought to the surface. Petroleum products are produced from the processing of crude oil or petroleum at refineries and the extraction of liquid hydrocarbons at natural gas processing plants. Petroleum is the broad category that includes both crude oil and petroleum products. The terms "oil" and petroleum" are sometimes used interchangeably [1].

Petroleum is formed when large quantities of dead organisms, usually zooplankton and algae are buried underneath sedimentary rock and subjected to intense heat and pressure that is, it is formed when the remains of marine algae and animals gradually settle on sea beds and over the years tend to be covered with mud, silt and other sediments which as the sediments are piled up, their mass exerts a great pressure on the lower layers, changing them to hard sedimentary rocks but due to bacterial activity, coupled with heat and pressure, it changes the plant and animal remains into crude oil or petroleum. Under normal conditions, PMS is a volatile liquid with a characteristic odour.

Over the years, adulteration of petroleum products has been a common trend in the world today notwithstanding its hazardous effects. Adulteration of petroleum products is an act perpetrated daily by unscrupulous people in the developing countries like Nigeria with the intention of maximizing profit in their business with total disregard of the hazardous effect their actions could have on end users [2]. According to Onojake *et al.* [2], adulteration is the deliberate mixing of petroleum products with partially refined products or condensates (reservoir gases that condense to liquid hydrocarbon when produced) with products that are in high demand like PMS, DPK with a singular aim of making more profit. PMS that are contaminated or whose quality has been weakened by adding inferior quality ones or products of lower grade are referred to as adulterated PMS. Adulteration of PMS mainly involves adding kerosene or diesel to the PMS. But this problem can be tackled if proper and regular analysis which involves the quality control tests is carried on the PMS to ascertain its composition.

Corresponding Author: C. Ikeora Onyinye, Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Due to the high demand of PMS, there are various agencies that are strictly based on the regulatory of petroleum products in Nigeria, some of them include;

- Department of petroleum resources (DPR); ensures that the quality of products are not compromised and that the products are also dispensed at the recommended prices.
- Petroleum product pricing regulatory agency (PPPRA); is responsible for ensuring petroleum products availability also for moderate price volatility and regulates the importations that are subsidy-based.
- Petroleum support fund (PSF); is a pool of funds budgeted by Federal Government to stabilize the domestic prices of petroleum products by paying for under-recovery subsidy.
- Petroleum equalization fund management (PEF); ensures uniformity in petroleum products prices when being dispensed to the ultimate users by paying bridging allowances etc. to the sellers of the products.
- Nigeria National Petroleum Corporation (NNPC); committed to ensuring safe transportation and distribution of the petroleum products to the Nigerian companies through its subsidiary Pipelines and products marketing company (PPMC).

According to Conaway [3], one cannot talk about the chemistry of PMS without understanding octane numbers. When PMS is burned in an internal combustion engine to CO_2 and H_20, there is a tendency for many gasoline mixtures to burn unevenly. Such non constant and unsmooth combustion creates a "knocking" noise in the engine. Knocking signifies that the engine is not running as efficiently as it could. It has been found that certain hydrocarbons burn more smoothly than others in a gasoline mixture. In 1927 a scale that attempted to define the "antiknock" properties of gasoline was created. At that time, 2,2,4-trimethylpentane (commonly called "isooctane") was the hydrocarbon that, when burned pure in an engine, gave the best antiknock properties (caused the least knocking). This compound was assigned the number 100, meaning it was the best hydrocarbon to use. The worst hydrocarbon researchers could find in gasoline (which when burned pure gave the most knocking) was n -heptane, assigned the number 0. When isooctane and heptane were mixed, they gave different amounts of knocking depending on their ratio: The higher the percentage of isooctane in the mixture, the lower was the amount of knocking. Gasoline mixtures obtained from petroleum were burned for comparison. If a certain gasoline has the same amount of knocking as a 90% isooctane, 10% heptane (by volume) mixture, we now say that its "octane number" is 90. Hence, the octane number of a gasoline is the percent isooctane in an isooctane-heptane. Thus, a high octane number means a low amount of knocking.

According to Arene and Kitwood [4] and Shammah [5], a poor quality fuel tends to ‘knock’ or explode unevenly and prematurely, especially in a high-compression engine. 2,2,4-Trimethylpentane is a good fuel, because it burns smoothly and does not cause knocking. It is, therefore, assigned the arbitrary octane number of 100 (on a zero-to-100 scale). On the other hand, heptane is a bad fuel, because it is particularly inclined to causing knocking. It is, therefore, assigned the octane number of zero. The octane number or octane rating of petrol is, therefore, the percentage of ‘iso-octane’ blended with heptane which reflects the knocking characteristics of the fuel. It is a measure of its performance in an internal-combustion engine. PMS is mainly used as a fuel for light road vehicles (cars, motorbikes and small vans) and small appliances (lawnmowers, cement mixers, etc.).

The aim of this research was to analyze premium motor spirit samples from three different oil depots in Lagos Metropolis, Nigeria.

MATERIALS AND METHODS

Samples of PMS were collected randomly from three different oil depots in Lagos Metropolis and analyzed to determine its composition and to check for adulteration. The materials used were100ml and 500 ml measuring cylinders, 700-750mmHg hydrometer, handheld thermometer, octane analyser, round bottom distilling flask, mercury in glass thermometer, distillation unit and sulphur analyzer.

Procedures: The tests carried out are based on the ASTM methods.

Density Test: The PMS sample was poured into the measuring cylinder of 500ml, after which the hydrometer was carefully cleaned and immersed into the product sample. The graduated stem rose vertically to give a scale reading. This reading was noted and recorded. The reading was not the actual product density but the observed density; because without the observed density the actual product density cannot be obtained.

The thermometer was also inserted into that same sample, which was left in it for about some minutes until no more change was noticed in the temperature reading, that is, when the temperature is said to be stable then the final temperature reading was noted which was the product temperature. The observed density together with the product temperature was used to check for the product actual density on the standard density table at 150C. The test method used here is also called the D1298 test that is, based on ASTM (American Society for Testing and Materials) method.

Research Octane Number (R.O.N) Test: The instrument used in carrying out this test is called the *OCTANE ANALYZER.* First the power was switched ON, the display then showed version number followed by a 15 seconds count down after which "Clear chamber and press Measure" appeared on the screen. The chamber was then covered with the light shield and the MEASURE key was pressed to standardize the instrument. After the "Reading" took place, "Put in sample" appeared on the display indicating that the instrument has been standardized and now ready for the sample to be measured.

The light shield was removed from the sample chamber; the filled PMS sample was then placed in the sample chamber, being careful to align the alignment stripe on the sample holder with the left alignment stripe on the instrument. The light shield was carefully replaced over the sample holder; this shield is always used when measuring a PMS sample otherwise, the result will be incorrect.

"Remove and Replace" was displayed when the MEASURE key was pressed that is after the "Reading" took place, the sample holder was removed and rotated to align the stripe on the sample holder with the right alignment stripe on the instrument and then the light shield was carefully replaced over the sample holder.

After the "Reading" took place, " Remove and press MEASURE" was displayed again, the sample holder was then removed and the empty chamber was covered with the light shield. The MEASURE key was pressed again and finally at this point, the results containing *(RON, ETHANOL AND BENZENE)* was printed by the instrument. The RON and the BENZENE test are also known as the D2699 and D3606 test method respectively based on the ASTM (American Society for Testing and Materials).

Distillation Test: 100ml of the PMS sample was first measured using the measuring cylinder and was gently poured into the flask. It was then allowed to cool for some minutes to avoid unnecessary fire outbreak since PMS is a very volatile liquid before the main test in the distillation unit was started. After the sample was cooled, the glass thermometer was placed inside the flask, which was then fixed into the fractionating column and heated by a small gas flame so as to produce 10ml of distillate every 4 or 5min. Meanwhile the measuring cylinder which served as the receiver was placed where the distillate was to be collected and the temperature of initial distillation (that is, Initial boiling point which is the thermometer reading at the neck of the distillation flask when the first drop of distillate leaves the tip of the condenser tube) was recorded; other distillation temperatures were observed when the level of the distillate reached each 10% mark on the graduated receiver (measuring cylinder), with the temperatures for the 5% and 95% marks included after which the final boiling point was noted and recorded. The machine used is a *DISTILLATION UNIT* and the method used is the D 86 test method.

Sulphur Content Test: Just like the octane analyzer, it consists of the LCD, sample holder, printer, keyboard and the light shield. After the machine was switched ON, the measured PMS sample was poured into the sample holder which looks very much like a beaker and was covered with the light shield which was then placed in the sample chamber for reading to take place (since the machine was already programmed for reading the exact amount of sulphur present in the sample). After like 5-6mins the machine printed the result showing the sulphur content in the PMS sample. The machine used is a *SULPHUR ANALYZER* and the test is also known as the D 4294 test.

RESULTS AND DISCUSSIONS

The results of the analysis carried on the PMS Samples are given as:

A.S.T.M stands for American Society for Testing and Materials: the official organization in the United States for designing standard tests for petroleum and other industrial products.

IP stands for Institute of Petroleum.

R.O.N stands for Research Octane Number: which aids in determining the knock rating, in terms of octane numbers of fuels for use in spark-ignition engines.

I.B.P stands for Initial Boiling Point: is the point or temperature at which the first drop of distillate appears after commencement of distillation in the standard ASTM laboratory apparatus (Distillation Unit).

F.B.P stands for Final Boiling Point: is the maximum temperature observed on the distillation thermometer when a standard ASTM distillation is carried out. The final boiling point has maximum limit of 210°C.

Recovery is the total volume of distillate recovered in the graduated receiver and residue is the liquid material, mostly condensed vapors, left in the flask after it has been allowed to cool at the end of distillation. The residue is measured by transferring it to an appropriate small graduated cylinder. Low or abnormally high residues indicate the absence or presence, respectively, of high boiling components.

Total recovery is the sum of the liquid recovery and residue. Loss represents the distillation loss, which is the difference, in the distillation between the volume of liquid originally introduced into the distilling flask and the sum of the residue and the condensate recovered. Simply put, the distillation loss is determined by subtracting the total recovery from 100%. It is, of course, the measure of the portion of the vaporized sample that does not condense under the conditions of the test. Speight [10].

The density obtained Results from Table 1 showed the physicochemical characteristics of three PMS samples based on its appearance, density, research octane number (RON), ethanol content, benzene content and the sulphur content. The density obtained was $0.7436 \pm 1.782\times10^{-3}$ which is within the ASTM density range (0.720-0.780), indicating that the samples are neither too light nor too heavy. The value of the RON which is the measure of the PMS ability to knock or ping in an engine is 92.3 ± 0.497 % which is above the RON minimal value of 90%. This is connected with adulteration which is a common practice. The implication of the low RON values is that the products of low grade are pushed into the market with low antiknock rating [6]. Knocking is the metallic noise usually observed in spark ignited engine as a result of low octane rating of PMS. High octane rating of PMS is necessary for better performance of the internal combustion engine [7]. Low octane rating of PMS could hinder engine power performance [8]. Ethanol was found to be absent via the ethanol content test. The benzene content test showed the concentration of substituted benzene in PMS samples as *0.933 ± 0.386%* which is within the range (2 max.) by ASTM, since benzene is classed as a toxic material and knowledge of the concentration of the compound can be an aid in evaluating the possible health hazard to persons handling and using the PMS. The sulphur content was obtained to be $0.0344 \pm 2.271\times10^{-7}$%. The quality many petroleum product is related to the amount of sulphur present. The knowledge of the sulphur concentration is necessary for processing purposes. Here, the value obtained is within the ASTM standards as it provides a means of compliance with specification or limits set by regulations for sulphur content in PMS [9].

The results of the distillation profile of the PMS samples are shown in Table 2, according to the American Society for Testing and Materials for PMS, the distillation profile is planned such that it shows the reported result in terms of the initial boiling point (which is the thermometer reading in the neck of the distillation flask when the first drop of distillate leaves the top of the condenser tube), the distillation temperatures; usually observed when the level of the distillate reaches each 10% mark on the graduated receiver, with the temperatures for 5% and 95% marks often included, the final boiling point (which is the highest thermometer reading observed during distillation, the recovery, the residue and finally the distillation loss. However, the initial boiling point (IBP) and final boiling point (FBP) are mainly considered [10]. The results obtained from the PMS samples in Table 2 based on the IBP and FBP are *39± 0.817°C and 204± 0.817°C* respectively which is also within the ASTM range on distillation.

Table 1: Physico-Chemical Characteristics of the PMS Samples

Test	Unit	Method Astm IP	Specification	Result for Pms Sample 1	Result for Pms Sample 2	Result for Pms Sample 3
APPEARANCE		Visual	Clear and Bright	Clear and Bright	Clear and Bright	Clear and Bright
DENSITY AT 15°C	G/ml	D1298 160	0.720-0.780	0.7432	0.7460	0.7417
R.O.N		D2699-07	90Min.	92.0	93.0	91.9
ETHANOL CONTENT		Octane fuel analyser	-	NIL	NIL	NIL
DISTILLATION	°C	D86 123				
BENZENE		D3606	2max	0.9	0.9	1.0
SULPHUR CONTENT		D4294	0.10max	0.0527	0.0418	0.0086

Table 2: Results of Distillation Profile of the PMS Samples

Test	Unit	Method Astm IP	Specification	Result for Pms Sample 1	Result for Pms Sample 2	Result for Pms Sample 3
Distillation	°C					
I.B.P			REPORT	40°C	39°C	38°C
5%			REPORT			
10%			70max	59°C	58°C	53°C
20%			REPORT	62°C	64°C	60°C
30%			REPORT	70°C	72°C	69°C
40%			REPORT	79°C	77°C	78°C
50%			125max	97°C	83°C	96°C
60%			REPORT	120°C	120°C	118°C
70%			REPORT	135°C	139°C	132°C
80%			REPORT	150°C	150°C	147°C
90%			180max	165°C	165°C	161°C
95%			REPORT	190°C	192°C	186°C
F.B.P			210max	204°C	205°C	203°C
RECOVERY			97%	99%	99%	98%
RESIDUE			2%	0.5%	0.5%	1%
LOSS			1.5%	0.5%	0.5%	1%

Table 3: Statistical Analysis of the Results

Test	PMS Sample 1	PMS Sample 2	PMS Sample 3	Mean $\bar{x} = \frac{\sum x}{n}$	Mean Dev. $\frac{\sum\lvert x-\bar{x}\rvert}{n}$	Variance $\frac{\sum(x-\bar{x})^2}{n}$	Stnd. Dev. $\sqrt{\frac{\sum(x-\bar{x})^2}{n}}$
Density	0.7432	0.7460	0.7417	0.7436	1.57×10^{-3}	3.177×10^{-6}	1.782×10^{-3}
RON	92	93	91.9	92.300	0.200	0.247	0.497
Ethanol Content	-	-	-	-	-	-	-
Distillation I.B.P.	40	39	38	39.000	0.667	0.667	0.817
5%	52	51	45	49.330	2.890	9.556	3.091
10%	59	58	53	56.670	2.443	6.889	2.625
20%	62	64	60	62.000	1.333	2.667	1.633
30%	70	72	69	70.330	1.330	2.436	1.560
40%	79	77	78	78.000	0.667	0.667	0.817
50%	97	63	96	92.000	6.000	40.67	6.377
60%	120	120	118	119.333	0.889	0.891	0.943
70%	135	139	132	135.333	2.433	8.222	2.867
80%	150	150	147	149.000	1.333	2.000	1.414
90%	165	165	161	163.667	2.667	7.113	2.667
95%	190	192	186	189.333	2.666	7.999	2.828
F.B.P.	204	205	203	204.000	0.667	0.667	0.817
Recovery	99	99	98	98.667	0.444	0.222	0.471
Residue	0.5	0.5	1	0.667	0.222	0.056	0.237
Loss	0.5	0.5	1	0.667	0.222	0.056	0.237
Benzene Content	0.9	0.9	1.6	0.933	0.244	0.149	0.386
Sulphur Content	0.0418	0.0527	0.0086	0.0344	0.017	5.160×10^{-14}	2.271×10^{-7}

CONCLUSION

The research has shown that the PMS samples are non-adulterated since the results of the analysis is within the ASTM (American Society for Testing and Materials) specifications as seen in table 1 and 2, the product samples are therefore said to bea very good product as explosions, engine malfunctions, failure of components are effects of using adulterated fuel.

Engine malfunctions can be as a result of 'knock' in the engine which is usually based on the octane rating of the PMS. Knock occurs when cylinder pressures are high. It is normal for an engine to ping a little at full throttle because cylinder pressures are very high at full throttle. Engine knock, however, should not be ignored since it can result in serious damage to the engine. High octane PMS burns slower than low octane PMS. The slow burn prevents engine knock when cylinder pressures are high. If an engine runs well and does not knock or ping on low octane PMS, there is no advantage in switching to higher octane PMS. If your engine knocks or pings, it does not necessarily mean something is wrong with the PMS (in most cases it is). It could be a problem with the engine's electronic control systems, ignition timing or exhaust gas recirculation. On a high mileage engine, a carbon build-up in the cylinders can increase cylinder pressures and cause knock.

From the findings and conclusion drawn from this research, it is imperative that regular quality assurance tests be conducted randomly on the PMS to check adulteration.

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REFERENCES

1. Meyers, R.A., 2004. Petroleum Handbooks. Petroleum Refining Processes. McGraw-Hill. New York, pp: 62-64.
2. Onojake, M.C., L.C. Osuji and N. Atako, 2012. Behavioural characteristics of adulterated Premium Motor Spirit (PMS); Egyptian Journal of Petroleum, 21: 135-138.
3. Conaway, C.F., 1999. A Nontechnical Guide to petrol: The Petroleum Industry. PennWell Publishers, pp: 53.
4. Arene, E.O. and T. Kitwood, 1979. An Introduction to the Chemistry of Carbon Compounds. Longman Group Ltd., London, pp: 125-127.
5. Shammah, B.K., 2006. Introduction to Automotive Spirit, Indian Academy Press, pp: 21.
6. Francis, W. and M.C. Peters, 1980. Manual on Fuel: Fuel Technology. Pergamon Press, New York, pp: 41-49.
7. Speight, J.G., 1999. Fuel Science and Technology. J.G. Speight. Marcel Dekker, New York, pp: 23-24.
8. Speight, J.G., 2000. Petroleum; The Chemistry of Petroleum products. WY,USA., pp: 1-9.
9. ASTM, 2007. Annual Book of ASTM Standards; American Society for Testing and Materials.
10. Speight, J.G., 2002. Handbook of Petroleum Analysis. Gasoline. John Wiley and Sons, New York, pp: 105-120.