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Analysis of the Quality of Petroleum Products from different Retail Outlets in Ughelli North, Delta State, Nigeria

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ABSTRACT

Physiochemical analysis of petroleum products was carried out on premium motor spirit (PMS), automated gas oil (AGO) and dual purpose kerosene (DPK) procured from two licensed (filling station) and one unlicensed (black-market) sales outlet. The parameters that were analyzed for specific gravity at 60°F, API gravity, density, kinematic viscosity, flash points, fire points, pour points, and cloud point. All tests were carried out using standard procedures of American Society for testing and materials (ASTM) and the results obtained were compared with reference standards from Nigeria National Petroleum Corporation (NNPC) laboratory. The experimental results for PMS, AGO and DPK across sampled sales outlet for specific gravity ranged between 0.74 and 0.75, 0.82 and 0.84, 0.74 and 0.81 for API gravity; 48.1 and 79.1, 33.8 and 77.0, 41.5 and 59.5; for Kinematic viscosity; 1.11 and 3.08, 3.33 and 5.33, 1.30 and 3.19 for AGO's pour point; 2.50 and 4.60 for AGO and DPK flash point; 51and 93, 22 and 52 for AGO and DPK fire point; 22 and 52, 24 and 54 respectively. The paper posited that there was large deviation in most of the physio-chemical parameters studied on the samples gotten from the unlicensed sales outlet (black market) suggesting presence of adulterants.

1. INTRODUCTION

Petroleum (or crude oil) is a complex naturally occurring liquid mixture containing more of hydrocarbons (hydrogen and carbon) but also containing some compounds of oxygen, nitrogen, and Sulphur.

Petroleum or crude oil is broken down into different products through fractional distillation which includes; gasoline, diesel, kerosene, Naphthalene, lubricating oil, etc. Petroleum or crude oil is classified as light, medium or heavy according to its density or more commonly as a number of degrees on the American Petroleum Institute gravity (API) scale, with higher numbers indicating lighter oil (Sivasakthi and Nagalaskshmi, 2018).

Crude oil analysis is essentially the chemical evaluation of crude oil feed stocks by petroleum testing in laboratories to determine crude oil type, its unique molecular and chemical characteristics. No petroleum /

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crude oil type is identical; and there are crucial differences in crude oil quality (Lois *et al*., 2003). Testing can include crude oil characterization of whole crude; and various boiling range fractions produced from physical or stimulated distillation. The information obtained from various petroleum analyses are used for detailed refining, engineering, and chart marketing purpose (El-Naggar*et al*., 2014).

Nigeria being amongst the largest crude oil producers in Africa has been at the fore front of oil refining in the Nation's three owned refineries located at Warri, Port Harcourt, and Kaduna respectively. The lack of maintenance of the refineries over two decades ago, has led to their total breakdown, thereby leading to the exportation of crude oil outside the shores of the country and importation of refined petroleum fraction (i.e., premium motor spirit; PMS, dual purpose kerosene; DPK, and automated gas oil; AGO) into the country with no interest of other fractions of petroleum due to the daily demand of the three products stated earlier. This leads to loss of revenue and foreign reserve to the country's economy. These petroleum fractions are usually imported by the Nation's oil corporation (NNPC) and independent marketers. Due to maximization of profit, some of the independent marketers tend to do shady practices that alter the quality of the petroleum products being distributed. This alteration is known as petroleum adulteration. Adulteration is done by introduction of illegal foreign substance that most likely include compounds that are already present in these fuels making it difficult to detect just by mere look, but with use of physio-chemical properties (Bhanu and Pankaj, 2017). These adulterated products are also carried out by some black-market outlet, whereby they buy petroleum products from legally established dispensing stations in urban areas and themselves introducing foreign substance to increase their yield for profit gain. When these substandard products get into dispensing outlets, their usage causes damage to engines of various kinds and may even causes explosion when used domestically e.g DPK used for cooking and lighting purpose in rural environment (Kehinde, 2011).

The objective of this research is to determine the quality and adulteration levels of PMS, DPK and AGO obtained from licensed dispensing outlets (filling stations) and from unlicensed sales outlet (black market) within Ughelli in Delta State, using physio-chemical parameters of petroleum products and comparing them with known reference standard from Nigeria National Petroleum Corporation (NNPC) laboratory.

2. MATERIALS AND METHODS

2.1 Obtaining of Sample

Three different samples each of petroleum fractions (PMS, DPK and AGO) with the total being nine samples in all were obtained from three outlets which include; two major licensed; LSO A&B (filling stations) and from one unlicensed sales outlet; USO (black market) within Ughelli, Delta State, Nigeria. Each of the samples was conserved in a labeled, clean, and air-sealed 2.5 litres amber bottle. At each sampling outlet, the amber bottle was rinsed with any of the petroleum product to be collected before introducing the sample into it after which all samples were transported to the petroleum laboratory for analysis.

2.2 Sample Analysis

The physiochemical parameters analyzed for were; specific gravity, API gravity, viscosity, flashpoint, fire point, pour point and cloud point. All these parameters were carried out following the American society's process for testing materials standard (ASTM) as well as comparing them with reference standard from Nigeria National Petroleum Corporation (NNPC) laboratory. All reagents used were of analytical grades.

2.2.1 Specific Gravity and API Gravity

The specific gravity of petroleum fraction is a factor that determines how heavy the products are to the weight of water.If the specific gravity of the product is greater than one (1) it means the product is denser than water and it would sink. But if less than one (1) it means the product is less dense than water (i.e. lighter than water) and it will flow on water. Petroleum products generally are lighter than water, and it flows on water. A lower specific gravity suggests a faster burning fuel, while a higher specific gravity suggests a slower boiling fuel (Sunoco Technical Bulletin, 2018). This is important because faster boiling fuels involves less spark advance than slower-burning fuels.

It's of note that densities of a substance are what bears unit in kg/m^{3}but specific gravity has no unit.

$$Specific\ gravity = \frac{Density\ of\ the\ Petroleum\ Product}{Density\ of\ the\ water} \quad (1)$$

The American Petroleum Institute (API gravity) helps in differentiating how heavy the petroleum products are. Petroleum products with higher API indicates lighter (low density) products and less sulphur content, while lower API suggests heavier products and high presence of sulphur content. This high sulphur content may be due to presence of adulterants to the already refined products.

$$API\ gravity = \left(\frac{141.5}{Specific\ gravity\ of\ the\ petroleum\ product}\right) - 131 \quad (2)$$

$The\ API\ does\ not\ have\ unit.$

The specific gravityat 60^{o}F and API gravity were determined using ASTM D4052-96 method (digital density analyser, Mettler Toledo, DA-100M).

2.2.2 Viscosity

This is the measure of resistance of flow of the products. PMS, DPK and AGO of low viscosity have a low resistance and shear easily making them flow easily, while high viscosity fluids resist friction and can cause damage to fuel pump (Ainul *et al*., 2012). The viscosity were determined at 40^{o}C using ASTM D445-06 method (Ubbeholde viscometer, anaka KV-4V/England DMO). It was measured in centistokes (cSt) unit.

2.2.3 Flash Point and Fire Point

Flash point and fire point were determined using ASTM D93-06 standard.The flash point is the lowest temperature at which a liquid can gives off vapor to form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material. For fire point, the temperature at which the flame becomes self-sustained as to continue burning when the ignition source is removed. The fire point is

usually a few degrees above the flash point. Its dependent on temperature hence was measured in degree celcius.

2.2.4 Pour Point and Cloud Point

The pour point and flash point were determined using ASTM D97-06 and ASTM D2500-05 method respectively (Tanaker pour point and flashpoint tester, Models MPC-102S). Cloud point is the minimum temperature at which wax cloud become noticeable in petroleum products when temperature is lowered. It serves as a key indicator of practical performance in automotive engines at low temperature. The pour point of a liquid is the temperature below which the liquid loses its flow characteristics. The high value of pour point means it can become semi-solid like at such temperature leading to jamming in machine when in use.

3. RESULTS AND DISCUSSION

The results from the physio-chemical properties carried out across sample areas for the petroleum fractions are presented in Table 1. Table 2 a-c gives the reference standard for each physio-chemical properties for PMS, AGO and DPK respectively.

Table1: Physio-chemical Properties of PMS, AGO and DPK for Licensed Sales outlet (LSO) A, B and Unlicensed Outlet (USO)

PARAMETERS	UNIT	LSO A			LSO B			USO		
		PMS	AGO	DPK	PMS	AGO	DPK	PMS	AGO	DPK
Spec.gravity @ 60ºF	-	0.74	0.82	0.78	0.75	0.84	0.74	0.67	0.84	0.81
API gravity	-	60.2	50.9	41.5	48.1	33.8	59.5	79.1	77.0	42.9
Viscosity	cSt	1.49	5.33	3.00	1.11	4.39	3.19	3.08	3.33	1.30
Pour point	ºC	-	3.00	-	-	2.50	-	-	4.60	-
Cloud point	ºC	-	-7.50	-	-	-7.90	-	-	-6.90	-
Flash point	ºC	-	51	26	-	93	52	-	58	22
Fire point	ºC	-	58	28	-	100.0	54	-	60	24

Table 2a: Reference Standard for Each Physio-chemical Properties for PMS

LOCATION	**Spec.gravity @ 60ºF**	**API gravity**	**Viscosity (cSt)**	**Pour point (ºC)**	**Cloud point (ºC)**	**Flash point (ºC)**	**Fire point (ºC)**
LSO A	0.74	60.2	1.49	-	-	-	-
LSO B	0.75	48.1	1.11	-	-	-	-
USO	0.67	79.1	3.08	-	-	-	-
Ref. Standard	0.75	57.10	1.00	-30.00	-20.00	28.00	36.00

Table 2b: Reference Standard for Each Physio-chemical Properties for AGO.

Location	Spec. gravity @ 60°F	API gravity	Viscosity (cSt)	Pour point (°C)	Cloud point (°C)	Flash point (°C)	Fire point (°C)
LSO A	0.82	50.9	5.33	3.00	-7.50	51	58
LSO B	0.84	33.8	4.39	2.50	-7.90	93	100.0
USO	0.84	77.0	3.33	4.60	-6.90	58	60
Ref. Standard	0.85	32.95	3.00	3.00	<4.40	90.00	98.00

Table 2c: Reference Standard for Each Physio-chemical Properties for DPK.

Location	**Spec. gravity @ 60°F**	**API gravity**	**Viscosity (cSt)**	**Pour point (°C)**	**Cloud point (°C)**	**Flash point (°C)**	**Fire point (°C)**
LSO A	0.78	41.5	3.00	-	-	26	28
LSO B	0.74	59.5	3.19	-	-	52	54
USO	0.81	42.9	1.30	-	-	22	24
Ref. Standard	0.83	41.2	2.00	-20.00	-10.00	50.00	54.00

The specific gravity at 60°F for PMS ranges from 0.67 to 0.74, AGO; 0.82 to 0.84 and for DPK ; 0.74 to 0.81 across the three sample outlets respectively. They are within the same range when compared to their reference standard of 0.75 for PMS, 0.85 AGO and 0.83 for DPK. However, for PMS sample from USO, DPK sample for LSO A and B a significant deviation was observed when compared to the reference standard. The API gravity for PMS, AGO and DPK ranged from 48.1-79.1, 33.8-77.0 and 41.5-59.5 for all sampled locations. The samples were neither too light nor heavy when compared to their reference standard. Although, there were major deviance from the reference standard when compared with that of PMS samples of USO, AGO samples for LSO A and USO and DPK for LSO B. The deviation seen in specific gravity and API gravity results, suggests shady practices carried out on the products and it's indicative of the potential danger in storing of the products in a region such as Nigeria (Otobrise, 2013).

The kinematic viscosity ranged from 1.11 to 3.08 for PMS, 3.33 to 5.33 for AGO and 1.30 to 3.19 for DPK samples. The kinematic viscosities reference standard for PMS, DPK and AGO are 1.00, 3.00 and 2.00 respectively. The kinematic viscosity for all samples were above their reference standard excluding DPK sample gotten from Unlicensed sales outlet (USO) which was below its ref. standard. The PMS, AGO, and DPK samples with high viscosity suggest adulteration with adulterant of high viscosity which can leads to attendant effects on injectors of vehicles thereby limiting their operational capacity (Seang-wock et al., 2002).

The pour point for AGO studied across sampled locations falls closer to the range, except in that of USO having results slightly higher than the reference standard. The cloud point all fell within the range of the reference standard. The flash and fire point recorded for AGO and DPK were generally below the reference standard making it very risky for

internal combustion of vehicles. Although AGO and DPK procured from Licensed sales outlet B, were slightly above the reference standard making it less risky and suitable for use.

4. CONCLUSION

This research work has shown that the physiochemical properties for petroleum products procured from unlicensed sales outlet (blackmarket) had great deviation when compared to the reference standard suggesting adulteration of the products, while the PMS, AGO and DPK samples procured from the two other studied location were generally within the physiochemical properties of their reference. Although there was noticeable deviations from specific gravity and kinematic viscosity of AGO and DPK from licensed sales outlet A&B.

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