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QUALITY ASSESSMENT OF PETROLEUM FRACTIONS FROM ROAD SIDE VENDORS AND ILLEGAL REFINERIES IN DELTA STATE

[1]K. O. Monago, *[2]C. Otobrise and [2] O. O. Emoyan

[1] Department of Pure and Industrial Chemistry,
University of Port-Harcourt, P.M.B. 5323, Port-Harcourt, Nigeria.

[2]Department of Chemistry, Delta State University, P.M.B.1, Abraka, Nigeria.

**Corresponding Author, Email: otocharles@yahoo.com*

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ABSTRACT

The levels of adulteration in Petroleum fractions of petrol (PMS), kerosene (DPK) and diesel (AGO) was studied. Samples were collected from road side vendors "black market" at Sapele and from two illegal refineries at Isaba and Bomadi. They were analysed for density at 15^0C, specific gravity at 60^0F, API gravity, Reid vapour pressure, kinematic viscosity, dynamic viscosity, gum content, cloud point, pour point, flash point, auto distillation and moisture content, using standard procedures of the ASTM. The results were compared with limits set by the Department of Petroleum Resources (DPR) in Nigeria. The physio-chemical properties of PMS from DPR limits ranged between 4.83-6.76% for density at 15^0C; 1.85-3.32% for specific gravity at 60^0F; -10.68- -5.95% for API gravity; 33.33-300% for Reid vapour pressure; -41.00- -23.00% for kinematic viscosity; -35.71- -15.71% for dynamic viscosity; -75.00- -40.00% for cloud point and <1% for flash point. The deviations of the same properties for DPK samples ranged between -0.12-0.86%; -1.09-0.12%; -2.84-1.77%; <1%; -33.00- -31.50%; -31.88- -29.88%; -130.00- -90.00% and -4.00-44.00%. Whereas the deviations of the same properties for AGO samples ranged between 4.39-6.59%; 0.78-3.01%; -8.95-3.19%; <1%; -18.67-55.00%; -19.62-56.54%; -87.50- -75.00% and -40.00-48.89%. It was concluded that the fraction were significantly adulterated.

Key Words: *Petroleum fractions, adulteration, black market, illegal refineries.*

INTRODUCTION

Fuel adulteration is the introduction of foreign substances into fuel illegally or unauthorized with the result that the product does not conform to the requirements and specifications of the product (NNPC, 2008). Adulteration of automobile fuels, leads to increased tailpipe emissions of hydrocarbons, carbonmonoxide, nitrogen oxides, particulate matter and the consequent ill effects on public health (Osueke and Ofondu, 2011; Yadav,et al., 2005; Fonseca et al., 2007). The primary cause of adulteration is greed fuelled by differential tax system on different petroleum fractions (World Bank, 2002; India CSE, 2002).

Premium motor spirit (PMS), dual purpose kerosene (DPK) and automotive gas oil (AGO); are the three major fractions of petroleum employed as energy sources in Nigeria for industrial plants, domestic use and transportation. These products are often adulterated with cheap products or by-products or waste hydrocarbon streams for monetary gains. For example, petrol is believed to be widely adulterated with naphtha, natural gas liquid, kerosene, waste solvents and so on (Igbafe and Ogbe, 2005). With a large number of adulterants available in the market (both local and imported) and the fact that adulterated products are difficult to detect at point of sale terminals (POS), the magnitude of these adulterations has grown to alarming proportions in recent times.

In Nigeria fuel consumers have unhindered access to petroleum products from various outlets which include; Nigerian National Petroleum Corporation (NNPC), licensed and unlicensed petroleum products filling stations, unlicensed surface tank operators (who locate surface tanks within residential areas), road side vendors (black market) and the very small mobile hawkers. The emergence of illegal refineries as a result of increasing demand for petroleum products like PMS, DPK, and AGO has continued to overwhelm the government, relevant authorities in the petroleum sector and security operatives in Nigeria. As long as their activities are shrouded in secrecy, they continue to turn out products of low quality and sometimes deliberately adulterate them to make more profit. Therefore, the objective of this research is to determine the quality and level of adulteration of some samples of petroleum fractions obtained from road side vendors (black market) in Sapele and two illegal refineries at Isaba in Warri south west and Bomadi in Bomadi local government areas of Delta state.

MATERIALS AND METHODS

Procurement of the Samples

Petroleum fractions (PMS, DPK, and AGO) were procured from road side vendors within Sapele. Similar samples were obtained from illegal refineries at Isaba in Warri south west and Bomadi in Bomadi local government areas of Delta state. This was achieved with the aid of local residents and security operatives who were destroying the illegal refineries. The samples were preserved in clean, air-tight plastic containers and taken for analysis in the water and oil laboratory of Eleme Petrochemical Company, at Eleme in Rivers state.

Analysis: The density at 15^0C, specific gravity at 60^0F and API gravity were determined using ASTM D4052-11 method (Digital density analyser, Mettler Toledo, DA-100M); kinematic viscosity at 40^0C was determined using ASTM D445-06 method (Ubbeholde viscometer, Tanaka KV-4V/England DMO); cloud point was determined by the ASTM D2500-05 method; pour point was detrmined by the ASTM D97-06 method; flash point was determined by the ASTM D93-06 method; moisture content was determined by the ASTM D1744-92 method; gum content was determined by the ASTM D381-04 method (Tanaka jet evaporation bath, model 1B-612N); Reid vapour pressure was determined by the ASTM D323-94 method; auto distillation was determined by the ASTM D86-05 method (Distillation apparatus, Tanaka Model AD-6). All reagents used were analytical grade.

RESULTS

The results for the determination of some physio-chemical properties of the petroleum fractions are presented in Tables 1-3

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Table 1: Some Physio-chemical Properties of the Petroleum Fractions from Isaba

Parameter	Unit	PMS	DPK	AGO
Density @ 15^0C	g/cm^3	0.7740	0.8190	0.8740
Spec. gravity @ 60^0F		0.7750	0.8200	0.8760
API gravity		51.0000	41.0000	30.0000
Reid vapour pressure	KPa	12.0000	<1	<1
Kinematic viscosity	cSt	0.7700	1.3700	4.6500
Dynamic viscosity	cP	0.5900	1.1300	4.0700
Gum content	mg/100ml	<5	<5	38500
Cloud point	^{0}C	-5	-1	10.0000
Pour point	^{0}C	<-34	<-34	5.0000
Flash point	^{0}C	<30	60.0000	134.0000
Moisture	ppm	56.0000	54.0000	95.0000

Table 2: Some Physio-chemical Properties of the Petroleum Fractions from Bomadi

Parameter	Unit	PMS	DPK	AGO
Density @ 15^0C	g/cm^3	0.7600	0.8230	0.8560
Spec. gravity @ 60^0F		0.7660	0.8260	0.8570
API gravity		53.0000	40.0000	34.0000
Reid vapour pressure	KPa	36.0000	<1	<1
Kinematic viscosity	cSt	0.5900	1.3600	2.4400
Dynamic viscosity	cP	0.4500	1.1200	2.0900
Gum content	mg/100ml	<5	<5	17500
Cloud point	^{0}C	-10	-1	5.0000
Pour point	^{0}C	<-34	<-34	2.0000
Flash point	^{0}C	<30	48.0000	58.0000
Moisture	ppm	87.0000	45.0000	81.0000

Table 3: Some Physio-chemical Properties of the Petroleum Fractions from Sapele

Parameter	Unit	PMS	DPK	AGO
Density @ 15^0C	g/cm^3	0.7630	0.8150	0.8620
Spec. gravity @ 60^0F		0.7640	0.8160	0.8630
API gravity		53.7000	41.9000	32.7000
Reid vapour pressure	KPa	32.0000	<1	<1
Kinematic viscosity	cSt	0.6100	1.3400	3.0500
Dynamic viscosity	cP	0.4700	1.0900	2.6300
Gum content	mg/100ml	<5	<5	25070
Cloud point	^{0}C	-12	3.0000	10.0000
Pour point	^{0}C	<-34	<-34	1.0000
Flash point	^{0}C	<30	72.0000	54.0000
Moisture	ppm	94.0000	123.0000	404.0000

Deviations of the physio-chemical properties of the petroleum fractions from DPR limits are shown on tables 4-6. They were calculated according to:

$$D = \frac{S-L}{L} X\ 100.$$

Where S = value of the physio-chemical property of the petroleum fraction; L = value of the DPR limit of the physio-chemical property of the petroleum fraction and D = deviations (%) of the physio-chemical properties of the petroleum fractions from DPR limits.

Table 4: Deviations of Physio-chemical Properties of PMS Samples from DPR Limits

Parameter	**Unit**	**DPR Limits**	**Deviations (%)**		
			Isaba	**Bomadi**	**Sapele**
Density @ 15^0C	g/cm^3	0.7250	6.76	4.83	5.24
Spec. gravity @ 60^0F		0.7501	3.32	2.12	1.85
API gravity		57.1000	-10.68	-7.18	-5.95
Reid vapour pressure	KPa	9.0000	33.33	300.00	255.56
Kinematic viscosity	cSt	1.0000	-23.00	-41.00	-39.00
Dynamic viscosity	cP	0.7000	-15.71	-35.71	-32.86
Gum content	mg/100ml	10.0000	<-50	<-50	<-50
Cloud point	^{0}C	-20.000	-75.00	-50.00	-40.00
Pour point	^{0}C	-30.000	<13	<13	<13
Flash point	^{0}C	28.0000	<1	<1	<1
Moisture	ppm	Not available	-	-	-

Table 5: Deviations of Physio-chemical Properties of DPK Samples from DPR Limits

Parameter	**Unit**	**DPR Limits**	**Deviations (%)**		
			Isaba	**Bomadi**	**Sapele**
Density @ 15^0C	g/cm^3	0.8160	0.36	0.86	-0.12
Spec. gravity @ 60^0F		0.8250	-0.60	0.12	-1.09
API gravity		41.1700	-0.41	-2.84	1.77
Reid vapour pressure	KPa	5.0000	<1	<1	<1
Kinematic viscosity	cSt	2.0000	-31.50	-32.00	-33.00
Dynamic viscosity	cP	1.6000	-29.38	-30.00	-31.88
Gum content	mg/100ml	10.0000	< -50	< -50	< -50
Cloud point	^{0}C	-10.000	-90.00	-90.00	-130.00
Pour point	^{0}C	-20.000	<70	<70	<70
Flash point	^{0}C	50.0000	20.00	-4.00	44.00
Moisture	ppm	Not available	-	-	-

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Table 6: Deviations of Physio-chemical Properties of AGO Samples from DPR Limits

Parameter	Unit	DPR Limits	Deviations (%)		
			Isaba	Bomadi	Sapele
Density @ 15^0C	g/cm^3	0.8200	6.59	4.39	5.12
Spec. gravity @ 60^0F		0.8504	3.01	0.78	1.48
API gravity		32.9500	-8.95	3.19	-0.76
Reid vapour pressure	KPa	1.9000	<1	<1	<1
Kinematic viscosity	cSt	3.0000	55.00	-18.67	1.67
Dynamic viscosity	cP	2.6000	56.54	-19.62	1.15
Gum content	mg/100ml	10.0000	$3.8x10^5$	$1.7x10^5$	$2.5x10^5$
Cloud point	^0C	40.0000	-75.00	-87.50	-75.00
Pour point	^0C	3.0000	66.67	-33.33	-66.67
Flash point	^0C	90.0000	48.89	-35.56	-40.00
Moisture	ppm	Not available	-	-	-

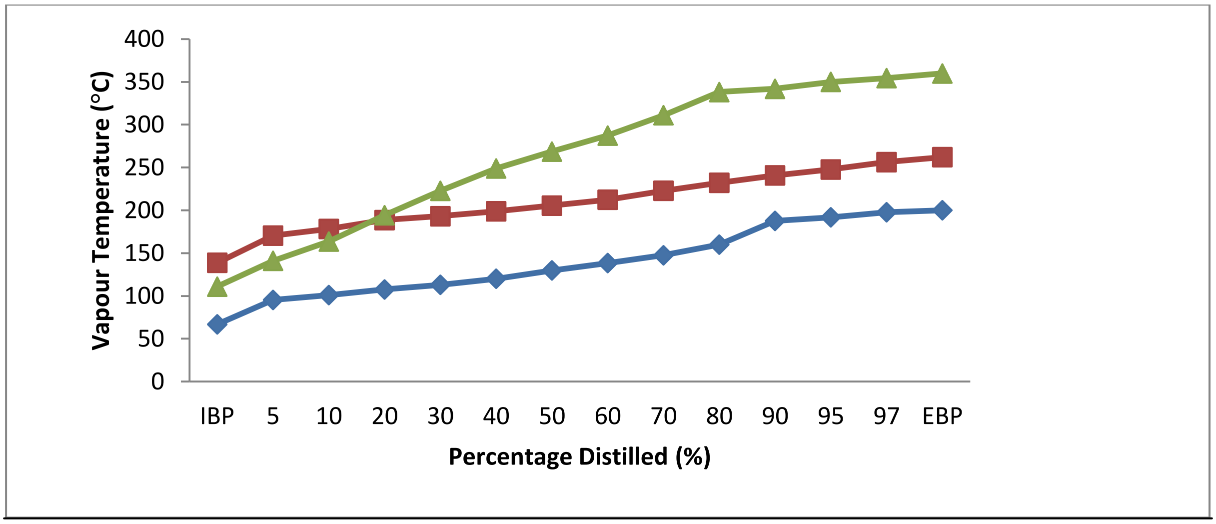

Figure 1: Distillation curves for PMS, DPK and AGO from Isaba.

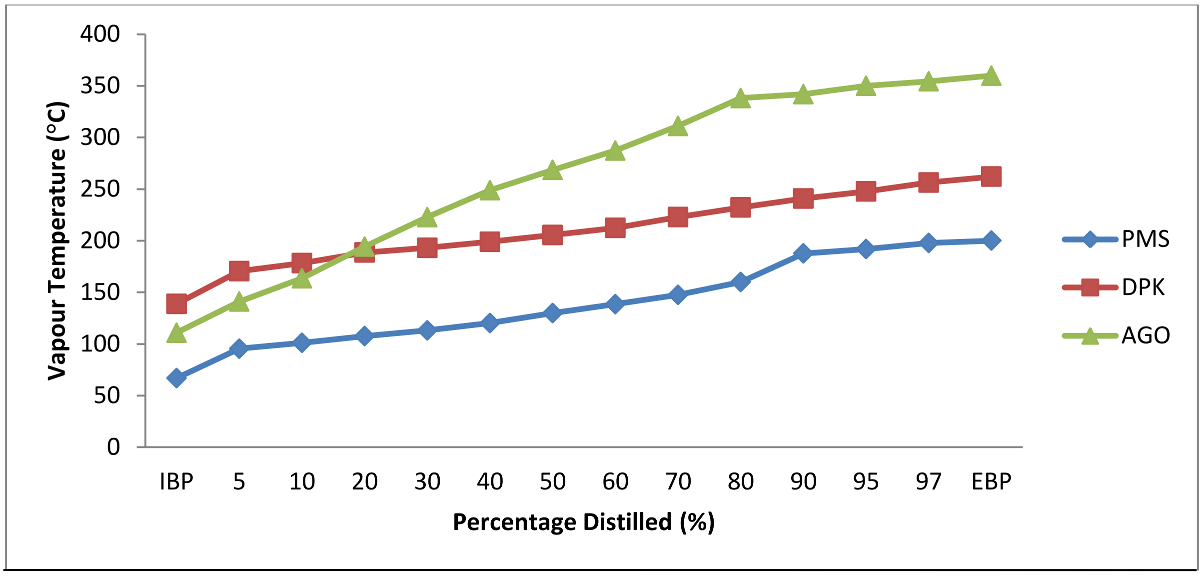

Figure 2: Distillation curves for PMS, DPK and AGO from Bomadi.

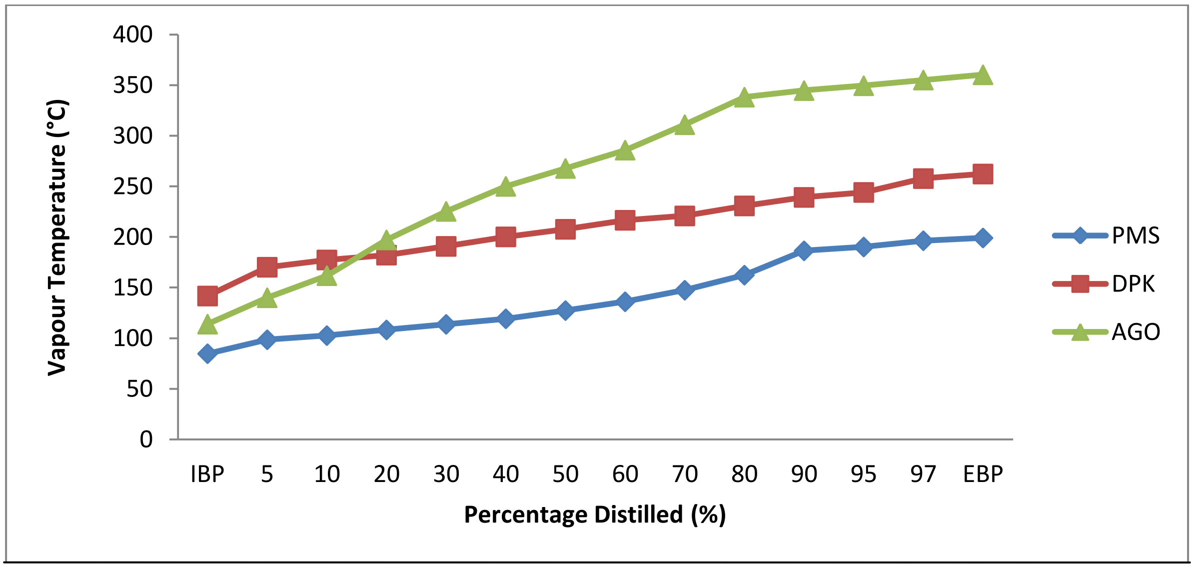

Figure 3: Distillation curves for PMS, DPK and AGO from Sapele.

IBP = Initial Boiling Point; EBP = End Boiling Point.

DISCUSSION

The density at 15^{0}C and specific gravity at 60^{0}F for all samples were above the DPR limits. The implication this portends for storage and handling of the petroleum fractions is negative. The specific gravity of the DPK sample from Isaba, was however below the DPR limit. The kinematic and dynamic viscosities as well as the cloud point of the PMS and DPK samples were below the DPR limit. However, a significant difference was observed for the AGO samples. For instance, the deviations from DPR limits of kinematic and dynamic viscosities for the AGO sample obtained from the illegal refinery at Isaba were as high as 55.00% and 56.54% respectively. The AGO sample from Sapele, showed smaller deviations of 1.67% and 1.15% respectively. While the deviations of the

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same properties for the AGO sample from Bomadi were below the DPR limit.

The Reid vapour pressure which is a measure of the volatility of gasoline was significantly above the DPR limit for all the PMS samples. The flash point of all the PMS samples was also above the DPR limit, thereby making the PMS samples risky for internal combustion engines. The deviations of the flash points of the DPK and AGO samples from DPR limits, were however irregular.

The distillation curves for PMS, DPK, and AGO from the two illegal refineries is presented in figures 1 and 2, while figure 3 represents the distillation curves for PMS, DPK and AGO procured from road side vendors. Expectedly, the curves indicate that AGO is a higher boiling petroleum fraction in comparison with DPK and PMS. The intersection of the DPK and AGO curves at between 10-30% auto distillation indicates the possibility of some adulteration.

Crude oil theft and the emergence of illegal refineries in Nigeria are deeply rooted. The Nigerian Navy destroyed 7,378 illegal refineries in six months (Okojie, 2013), while the Joint Task Force (JTF), destroyed 3,778 in one year (Obada, 2013). It is obvious that destroying these illegal refineries is tantamount to fighting an intractable battle. With the depletion of ozone layer and increasing global warming, it is disheartening to see security operatives confiscate and set ablaze these illegal refineries. Instead of burning them, the government should start to improve on the technology these indigenes are using and try to empower them and if possible employ them.

The findings of this research revealed that the level of adulteration of the petroleum fractions procured from road side vendors was significant. The study also revealed that the petroleum fractions obtained from the illegal refineries are of poor quality. The samples did not meet the products specifications for parameters like density at 15^0C, specific gravity at 60^0F, Reid vapour pressure for PMS, kinematic and dynamic viscosities for AGO and flash point for PMS and some DPK and AGO samples.

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