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COMPARATIVE STUDY OF PHYSICOCHEMICAL PARAMETERS OF SOME CRUDE OIL AND PETROLUEM PRODUCTS

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Abstract

Physicochemical analysis of crude oil and petroleum products were carried out on two different samples of crude oil and eight different samples of petroleum products. The parameters tested were specific gravity, API determination, aniline point, kinematic viscosity, water content, distillation profile, flashpoint, pour point and metal content determination. The tests were carried out using standard procedure of American society for testing and materials (ASTM). The result shows that the crude oils were different in terms of API gravity and specific gravity.API gravity of 36.2 and 31.5 respectively for crude oil C1 and C2 shows that they are not heavy crude oil. The low water content and low viscosity of the crude oils lower the risk of pipe and container corrosion and flow difficult. API gravity of gasoline and kerosene was more than 30, while that of engine oil and diesel oil was more than 30.For petroleum products, the result of density, specific gravity, viscosity and kinematic viscosity shows the value of those parameters increase from light fraction to heavy fraction. The pour point and flash point recorded for light fractions was lowered than that of heavy fractions, for both samples of gasoline P1 and P2, flash point is 49.3 ºF and 51.1ºF while pour point is -3 ºC and -5 ºC respectively, for Diesel oil D_1 and D_2 flash point is 244.2 and 240.2 ºF and pour point is +3.2 and +3.0 ºC respectively. The distillation profile result of both samples of gasoline, showed the temperatures to be in normal range. The level of heavy metal analysed were generally low but metal such as iron, copper, zinc were in abundance in the samples of the crude oil and petroleum products. The results are discussed in terms of importance and implication.

Keywords: crude oil, petroleum products, physicochemical, API gravity, metal content.

Introduction

Crude oil or petroleum is naturally occurring mixture, consisting predominantly of hydrocarbons with other elements such as sulphur, nitrogen, oxygen and some other metals appearing in form of organic compounds which in some cases form complexes with metals (Carey, 2003). Over the years the chemical utilization of crude oil and its refined products has been used on the increasing globally (Udeme *et al.*, 2012). It has been mentioned that the ever increasing chemical utilization of crude oils and petroleum products call for a better knowledge of the composition, structure and properties of the fractions (Olajire and Oderinde, 1992; Odebunmi *et al.*, 2001). As a result, concerted effort are being made to understand its composition, structures and properties. This understanding guides in processing method and condition to improve the yield and the quality of products.

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Composition of crude oil determines their characteristics (Carey, 2003). These characteristics in turn for any crude oil depend on the particular source of oil field. There are different multiple sand reservoirs of tertiary sedimentary deposits in each of oil field, resulting in a unique character of crude oil content. The oil fields are characterised by these differences. As a result, different proportions of the various hydrocarbons of different molecular types, sizes and other elemental constituents in the samples of the crude oil. Therefore there is need to characterize the oil to ascertain their properties, to design the precaution modality, refining procedure and assess its potential as a source of environmental contaminants (Udeme *et al.*, 2012).

It has also been established that the quality of the petroleum products plays the major role in consumer demand and the performance of the refineries (Oyekunle *et al.* 2004). Physico-chemical properties determination is a tool in identification of the source oil well and class of the crude oil (Ali *et al.,* 1989; Robert *et al.*, 1995; Olajire, 2013).

This study was therefore carried to determine and compare the physicochemical parameters of the crude oils and petroleum products. The physical parameters studied are kinematic viscosity, specific gravity, API gravity, water content, flashpoint, aniline point, pour point and ASTM distillation cracking point. The chemical parameters are metal ion content determination such as Fe, Cu, and Zn ions. These are the parameters which are often determined in crude oil (Udeme *et al.*, 2012).
This was carried out necessarily in view of the importance of crude oil in the socioeconomic life of man, there is need for checking and monitoring the quality of crude oil and petroleum products.

Materials and Methods

The samples were crude oil and petroleum products; the crude oil C1 and C2 were from different oil wells. The petroleum product were two different samples each of kerosene, petrol, diesel, engine oil making eight samples and were coded as K1 and K2 for kerosene, P1 and P2 for petrol, D1 and D2 for diesel, and E1 and E2 for engine oil. The samples were from different processing companies.

The physicochemical properties were determined by ASTM Methods as follows:-

The density specific gravity and API gravity were determined using a density bottle. This was cleaned, rinsed with distilled water and oven dried. The weight of the empty bottle was determined at a certain temperature. A $10cm^3$ sample of crude oil or petroleum product was filled into the density bottle and weighed at the same temperature the weight of an equal volume of water in the same density bottle was determined. The difference between the weights of the empty and filled density bottle gave the weight of the sample at the test temperature. Then this was used to calculate the density and specific gravity of each sample. The API gravity of each sample was also calculated using equation,

American Petroleum Institute (API) gravity = (141.5/S.G) -131.5,

Where S.G. is the specific gravity. (ASTM, 2011; API, 2011; Roussel and Boulet, 1995)

Viscosity determination follows the ASTM method. This involves measuring the flow time period of the sample between two marked points on the Ostwald viscometer (N535 Cofleu brand) and calculating the viscosity by using the standard equation. (ASTM, 2011)

The aniline point determination involves heating the sample in a test tube until the two become miscible. The mixture is then cooled at a controlled rate and the temperature. The minimum temperature at which the two phases separate was taken to be aniline point.

Distillation determination involves using the distillation machine (SS En ISO 3405), Using the distillation machine involved changing the disc, thermometer and plate in the distillation unit according to the petroleum products. The distillation properties of the sample at atmospheric pressure were determined according to SS En ISO 3405 in line with ASTM method. The water content determination follows the ASTM method by using the dean and stark apparatus.

Pour point determination was carried out by heating the sample in a test tube then cooled in a cooling bath at a constant rate. The lowest temperature at which there lost of fluidity in the sample marked the pour point.

Flash point was carried out using Pensky Marters (ISO 2719) closed cup flash point apparatus. The test flame is put to use with every 1^{o}C rise in temperature to establish vapour evolving with heat.

Metal content determination.

A 10g sample of crude oil was weighed into a porcelain crucible, the sample was pre-ashed before putting it into the muffle furnace at 500^{o}C for one and a half hours. When the ashing was completed, the residue was gently warmed with 10cm^2 of nitric acid (25%v/v). In order to facilitate the complete extraction, a glass rod was used to stir and crush the entire acid soluble element in the ashes. The slurry was then filtered into 100cm^3 volumetric flask, and the residue was further washed with 10cm^2 of nitric acid (25%v/v) solution. This was diluted with water to calibration mark. The slurry was analysed using atomic absorption spectrophotometer. These procedures were also used for all the petroleum products analysed AOAC (2012),

Statistical Analysis

Each analysis were carried out in triplicate, and for each parameter the means value of the three replicates were recorded for the respective parameter. The student t-test was used for statistical analysis. Difference was considered significance if the value of P was less than 0.05.

Results and Discussion.

Table 1 gives the physicochemical parameters of crude oil and petroleum products, Table 2 shows the results of metal analysed in the crude oil and the petroleum products, while Table 3 displays the distillation profile for the two samples of gasoline. The values of density, specific gravity, viscosity and API gravity of crude oil as shown in table 1 with C1 values lower than C2 values. The specific gravity gives a rough measure of the amount of the lighter hydrocarbon present, the lower the specific gravity the higher the API gravity (Roussel and Boulet, 1995).

API gravity determines the grade or quality of crude oils. Generally crude oil samples with API gravity greater than 31 are classified as light crude oils, those with API gravity between 22-31 are classified as medium crude while those with API gravity of 20 or less are referred to heavy crude oil (Oyekunle and Famakin, 2004; SSFL, 2012). The observed API gravity result for C1and C_2 is 34.2 and 31.5 respectively. This is an indication that both were not heavy crude oil but between light and medium crude oil (Udeme *et al*., 2012). This also indicates tendency for a low deposits of sulphur present, referred to as sweet crude (Odebunmi *et al.*, 2001). The percentage sulphur content of crude oil is known to increase as specific gravity increases because sulphur is a heavy element, its presence is said to add to the specific gravity of oil. (Udeme *et al*., 2012; Ghulam, 1990). Also for the petroleum product i.e. the distillates, the result of density, specific gravity, viscosity and kinematic viscosity is included in Table 1. The pour point and flash point recorded for light fraction is lowered than heavy fraction, for both samples of PMS (Premium Motor Spirit) P1 and P2, flash point is 49.3^{o}F and 51.1^{o}F while pour point is -3 ^{o}C and -5 ^{o}C respectively, for Diesel oil D_1 and D_2 flash point is 244.2 and 240.2 ^{o}F and pour point is (+3.2 and +3.0) ^{o}C respectively. The data shows the value of those parameters increase from light fraction to heavy fraction. (SSFL, 2012; Brown, 2013).

Knowledge of water contents is important in refining, purchasing and sale of crude oil because of corrosion associated with this parameter (Ghulam 1990; Udeme *et al.*, 2014). The data show that the two sample of crude oil C_1 and C_2 has 0.08 and 0.09% respectively. The values of water content were appreciably low in all the samples in line with Appending *et al.* (2013) and as compiled by Brown, (2013). The water content in the distillate increases from lighter fraction to heavy fraction. Crude oil with low water content implies low or minimal microbial growth and reduced the tendency to retain water soluble salts (Appenting *et al.,* 2013). Water in the crude oil leads to corrosion of the plant, water in crude oil is either in form of emulsion or in large droplets (Verkoczy and Kamal, 1989). Viscosity is the measure of internal friction of a liquid which is the resistance of the liquid to its flow; it therefore indicates the flowing ability of crude oil from one point to another (Olajire, 2013). When compared to related result of Ghulam *et al*. (2013), the result of the viscosity shows that the two samples of crude oil has a relatively low viscosity 7.25 and 7.37 respectively. This implies that they have the ability to flow rapidly during spillage. The knowledge of viscosity is required to enhance transportation, in reservoir stimulation as well determining the structure of liquid. Viscosity measurement helps in the pump design. It also gives the rough idea about the different fractions of crude oils (Ghulam *et al*., 1990).

Generally the results of the physicochemical properties of petroleum products shows that the values of some parameters of petroleum products increase from the sample of gasoline to engine oil (P1, P2, K1, K2, D1, D2 to E1, E2), while the API gravity was reverse (decrease from gasoline to engine oil). API gravity of gasoline and kerosene was more than 30 while that of engine oil and diesel oil was less than 30 this is an indication that engine oil are heavier than gasoline. Further more the result of aniline temperature of less than 60^{o}C shows that the samples were low in aromatic hydrocarbon. (Nafi'u *et al*., 2012)

The result of the heavy metal content of crude oil and petroleum products are recorded in Table 2. The levels of the analysed heavy metal obtained in the exercise were generally low. The low metal content in the two sample of crude oil agree with the reports that light crude oil sample as against heavy crude oil usually contains relatively low metal (SSFL, 2012; Udeme *et al*., 2012). The presence of heavy metals were also recorded in some petroleum products (Table 2). Heavy metal in petroleum products is not expected and should be reduced to tolerable amount, hence the need to reduce the concentration of metals in feedstock for catalytic cracking and reforming and other processes for the petroleum products (Komine,1997; Odebunmi *et al.,* 2001). These metal indices vary from one petroleum product to another, and provide a means of differentiating petroleum product samples (Tomoike, 1997; Nafi'u *et al.,* 2012)

For the distillation profile for P1 and P2 (Table 3), distillation is one of the most important parameters as long as quality is concerned (Wang *et al*., 2003). It rates the evaporation of the petroleum products and the performance as a function of tray number during fractional distillation. The boiling point of the distillation as observed shows that the fractions increased as the volume percent of the fraction, when comparing this observation with that of kerosene, a boiling point higher than this was obtained. The distillation profile result of the two products P1 and P2, showed the boiling point of the distillation fraction increases as the volume percent of the fraction increases (SSFL, 2012; Odebunmi *et al*., 2001)

Table 1: ANALYSIS RESULTS OF CRUDE OIL AND PETROLUEM PRODUCTS

Parameters.	C1	C2	PI	P2	K1	K2	E1	E2	D1	D2
Density (g/cm^3) @ 26^{o}C.method D1298, IP160.	0.832	0.918	0.735	0.753	0.817	0.733	0.886	0.899	0.839	0.843
Specific gravity @ 26^{o}C	0.814	0.899	0.727	0.744	0.808	0.802	0.885	0.889	0.830	0.835
API gravity @60^{o}C	31.5	36.5	63.1	58.6	43.6	44.9	28.4	27.7	38.9	37.9
Kinematic viscosity (csts) @100^{o}F	7.25	7.37	0.20	0.10	ND	ND	18	18.3	4.12	3.02
Aniline point(^{o}C)	56.3	53.9	57	ND	50	44	ND	ND	52	54
Percentage Water content.(V/V)	0.08	0.09	0.01	0.01	0.02	0.03	0.06	0.05	ND	ND
Pour Point (^{o}F)	ND	ND	-3	-5	+2.0	+2.2	+3.8	+3.5	+3.2	+3.0
Flashpoint @49^{o}C. Method ASTM D93	ND	ND	49.6	51.1	95.2	97.0	251.3	255.1	244.1	240.2

N.D: Not Determined

Table 2: Heavy metal content of crude oil and petroleum products.

No	ID NO	Mn (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Co (ppm)	Cr (ppm)	Pb (ppm)	Ni (ppm)
1	C1	0.00	0.10	0.01	0.18	0.00	0.00	0.00	0.00
2	C2	0.00	0.10	0.00	0.18	0.00	0.00	0.00	0.00
3	P1	0.00	0.20	0.00	0.13	0.00	0.00	0.00	0.00
4	P2	0.00	0.23	0.03	0.31	0.00	0.00	0.00	0.00
5	K1	0.00	0.10	0.00	0.28	0.00	0.00	0.00	0.00
6	K2	0.00	0.10	0.03	0.26	0.00	0.00	0.00	0.00
7	D1	0.00	0.20	0.02	0.12	0.00	0.00	0.00	0.00
8	D2	0.00	0.11	0.00	0.17	0.00	0.00	0.00	0.00
9	E1	0.00	0.10	0.01	0.44	0.00	0.00	0.00	0.00
10	E2	0.00	0.22	0.00	0.38	0.00	0.00	0.00	0.00

TABLE 3: Distillation profile of Gasoline P1 and P2

TEST	P1	P2
DISTILLATION IBP °C	40	45
5%	50	51
10%	58	54
20%	64	59
30%	67	64
40%	77	76
50%	89	92
60%	104	129
70%	119	124
80%	136	139
90%	154	161
95%	171	176
FBP	203	203
RECOVERY	99%	99%
RESIDUE	0.5%	0.5%
LOSS	119	0.5%

CONCLUSION

The result has shown that samples of the crude oil and petroleum products varied in terms of API gravity and specific gravity. The petroleum products decreases in specific gravity from gasoline but increases in specific gravity in diesel oil, the low viscosity obtained shows that it can be easily transported through pipelines without the necessary addition of diluents at regular intervals often associated with heavy crude oil samples. However the low viscosity associated with this oil blends implies that crude oil obtained in Nigeria can easily flow and spread out causing oil spillage in the environment. The crude oil and petroleum products showed the presence of heavy metals such as iron, copper, and zinc, the nature of this metals. Their abundance in petroleum products may probably provide information on the origin, migration and maturation of raw material of these petroleum products. It also indicates the regional geochemical prospecting base as well as the processing and storage channels in the refinery.

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