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CHARACTERISTICS AND PHYSICOCHEMICAL PROPERTIES OF A NIGERIAN PETROLEUM PRODUCT SAMPLE EVALUATED VIA LABORATORY PILOT SCALE DIGITAL TOOL KIT

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ABSTRACT : *Characterization of Petroleum Product Samples is an activity carried out to measure and document the physical and chemical properties of the crude oil sample as to serve as a guide in the future monitoring of the oil/gas reservoir content as well as give an insight as to the quantity of the produced fluid from the well head in terms of the various fractions realizable when the product is subjected to processes leading to a refined and usable substance. A petroleum sample was collected from the opuekeba field (50 litres) located in the swamp portion of OML-49, 14 kilometers east of Isan field and 6 kilometers west of opuama field at Ulaje village – Ondo State and subjected to continuous rectification using a pilot scale digital column distillation tool kit housed in the laboratory. Opuekeba field has 135ft net oil and 65ft net gas in the reserves with production capacity of 48.98 million barrels of oil and recoverable reserves of 36.95 million barrels of oil with about 68 million standard cubic feet of gas and 4.09 million barrels of condensate. Some of the evaluated physico-chemical properties include specific gravity (0.8705) basic sediment and water (BS & W) (20%) carbon residue (2.05%), API gravity (31o). The chemical properties includes sulphide as H2S (Nil) dissolved oxygen (Nil) turbidity 3.6 NTU, conductivity (8.77 ohm meter) PH (8.8), sodium Na+ (1796 mg/L) calcium ca2+ (Nil) hardness' (100mg/l) cadium cd (Nil) copper, cu (Nil), bicarbonate, HCO3 (1866) sulphate SO42+ (Nil) total dissolved solids (5319mg/l), chloride Cl- (1512mg/l). The results showed that the non-presence of hydrogen sulphide which posses health hazards and environmental corrosion imply the crude oil is within the grade referred as sweet crude since it has no sulphur content hence will have little or no environmental problems. One litre of this product sample was distilled and gave gasoline 300ml (30%) kerosene 260ml (26%) Gasoil 180ml (18%) and Residue 260ml (26%).*

KEYWORDS*: Digital tool kit, characterization, chemical property, physical property, rectification.*

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I. INTRODUCTION

The petroleum product sample (opuekeba oil) was located in a swamp portion of an oil field OML – 49 discovered in 1978 by an oil company operating in Nigeria, 14 kilometers east of 1san field and 6 kilometers south west of opuama field. The well drilled in this reservoir, opuekeba.1 has 135feet net oil and 55ft net gas in the hydrocarbon bearing sand. The opuekeba field is located in the southwest part of Nigerian in a village, Ulaje, Ondo State which falls within the Niger Delta basin which stretches from Lagos to Anambra and then from Delta State to Rivers, Cross River, Imo, Abia and Bayelsa States. The STOOIP as at the time of discovery was 47.98million barrels of oil and recoverable reserves of 36.93 million barrels of oil with about 67.62 billion cubic feet of gas and 4.08 million barrels of condensate. Initial production from the field was limited to about 13.87

million barrels of oil and the average rate was 16620 barrels / day oil and 17% water cut. Characterization is a foremost activity carried out to measure and document the physical and chemical properties of the crude oil as to serve as guide in the time to time monitoring of the reservoir. It will also give an insight of the crude oil quality in terms of the petroleum fractions realizable from atmospheric distillation of the product sample. Characterization could enable the process engineer design adequate surface facilities and piping network that will guarantee and safeguard the initial fluid separation processes when this is carefully carried out will help in the protection of lives of the people as well as the oil field environment. This is known as hydrocarbon assay or finger printing. Crude oil as it comes from the well head is preheated to about 60oC to break the emulsion and to facilitate the settlement of water, salt and silt at the bottom of the floating roof tank (Gatlin, (1960). Gas and oil which has the least density floats on top while water and silt are flushed out from below. Salt is removed at the de-Salter unit. When the impurities are carefully removed the crude is pumped to the fractionating column for continues rectification or distillation. This is a tall tower containing a series of equal spaced perforated trays, each perforation being fitted with bubble cap. The column is also provided with off-take pipe at intervals from which the various fractions are withdrawn. Condensed liquid collects on the plates and as the ascending vapor passes through, the liquid strips it of its more volatile components and at the same time looses its less volatile components by condensation (Ikezue, 2013). This process is repeated at each tray with the result that the vapor becomes increasingly superior or richer in the more volatile components as it ascends the rectification or fractionating column. The descending liquid becomes richer in the less volatile component; hence the lighter fractions condense and collect at higher temperatures in the fractionators (Ohams, 1996).

In the straight run distillation, the distillates collected are as follows:- natural gas, gasoline fraction, naphtha, kerosene and gas-oil. In vacuum distillation the products are usually lubricating oils and residues which are treated for the production of bitumen or asphalt.

When oil is produced to the surface, it requires further processing, purification and treatment before it could be sold or refined. The produced crude oil is usually a mixture of substances ie oil, gas and water which are required to be separated (Bradley, 2003). When the individual components are separated in a vessel called separator, water which is usually salt water is disposed properly in such a way it does not harm the environment. Gas is delivered to the gas vessels where further purification produces petroleum gas LPG such as ethane, propane, butane and other hydrocarbons (Adebayo, 2013). To evaluate the content and physic chemical properties of crude oil, refiners conduct assays also known as characterization of the petroleum product sample, (Nelson, 1949).

The evaluation is meant to serve several purposes and uses, that is,

(a) To detect content changes over time in an oil whose properties are known
(b) To decide whether the crude oil will yield desirable amount and qualities of products
(c) To plan the processing of the crude oil sample in an existing or new plants.
(d) To compare the produced oil sample with the oils of competitors and asses the market value.

A whole sample of crude oil may be evaluated for properties such as AP1° gravity, viscosity, sulphur content, percent water cut, pour point, colour, carbon content determination, ash content determination, smoke point, Aniline point etc. These basic properties could be defined as follows:

(i) **Flash point** and fire point the fire point and flash point can be taken as indirect measure of volatility of the product. The flash point is the lowest temperature at which the application of test flame causes the vapor above the oil to ignite. The fire point is the lowest temperature at which the oil ignites and continues to burn for 5 seconds. Petroleum products having low flash points are potential to fire hazards.

(ii) **Smoke point:** Smoke point is the maximum flame height in mm at which the fuel will burn without smoking when determined in a smoke point a apparatus under specified conditions

(iii) **Viscosity:** kinematic viscosity is defined as the measure of the resistance to gravity flow of a fluid. The pressure head being proportional to the density. Dynamic viscosity also known as absolute viscosity is the ratio of applied shear stress to rate of shear and thus a measure of the resistance of a fluid to flow/.

The unit of dynamic viscosity is the poise or centipoises while the unit of kinematic viscosity is cm^2/s or stoke.
Dynamic viscosity may be obtained from kinematic viscosity by multiplying it by the density of fluid at the temperature at which measurement was made.

(iv) **Cloud point and pour point:** cloud point of a petroleum product sample is the temperature at which a cloud or haze of wax crystals appears at the bottom of the test jar when oil is cooled under prescribed conditions.
Pour point is the lowest temperature expressed in multiple of 3°C at which the oil is observed to flow when cooled and examined under prescribed conditions. Pour point is the established test to estimate the temperature at which a sample of oil becomes sufficiently solid to prevent its movement by pumping. The pour point indicates the waxy nature of the oils.

(v) **Carbon residue:** This is defined as the amount of carbon residue left after evaporation and pyrolysis of an oil and is intended to provide some indication of relative coke forming tendency. Carbon residue gives a measure of carbon depositing tendency of a fuel oil when heated in a bulb under prescribed conditions.

(vi) **Density and specific gravity:** Density of a fluid is its mass per unit volume specific gravity is the radio of the density of a fluid to that of water at some temperature. Temperature specified is usually 15.56°C In USA specific gravity of oil is often expressed as degrees API. API gravity is related to the specific gravity of the petroleum product according to

$$\text{Degrees API} = \frac{141.5}{\text{sp.gr at } 15.56^{o}\text{C}} - 131.5$$

The specific gravity is an indication of the type / hydrocarbon present being highest for aromatics and lowest for paraffin's.

(vii) **Aniline point:** Aniline is a poor solvent for aliphatic hydrocarbons and excellent one for aromatics, aniline point of an oil is the lowest temperature at which the oil is completely miscible with an equal volume of Aniline. High aniline point indicates that fuel is highly paraffinic and hence has a high diesel index and very good ignition quality. In case of aromatics the aniline point is low and the ignition quality is poor.

II. MATERIALS AND METHODS

A. MATERIALS

The materials utilized consist of 50 litres Opuekeba oil sample from swamp Isan field OML-49, digitalized fractionating tool kit, Atomic Absorption Spectrophotomer, Specific Gravity Bottle, Digital Hydrometer, Weight Balance, Colorimeter, Chronometer Gas-Liquid Chromatographer. Digital Engler Viscometer, Smoke Point Apparatus, Laboratory Thermometer, Water Bath, Conical Flasks Crucibles, Refractometer, Muffle Furnace, Flash Point Apparatus, 6ml Aniline Sample, Pour Point Apparatus And Cloud Point Apparatus.

B. METHOD

About 50 litres of the petroleum sample was collected at the manifold inlet and inhibitors for corrosion and chemical emulsifiers were introduced and the sample characteristics were determined ie (a) specific gravity (b) Basic sediment and water (BS & W) (c) pour point (d) Flash point (e) viscosity (f) APIo gravity (g) carbon residue (h) associated water.

The produced water associated with the petroleum product sample was extracted and the following physicochemical properties were determined (a) Dissolved solids (b) hardness (C) Turbidity (d) Metals (e) pH (f) Specific gravity (g) Sulphur content (h) Conductivity (i) Anions (j) Cations.

III. RESULTS AND DISCUSSION

The results obtained at the experimental analysis are shown in tables 1 and 2 for the physico-chemical properties and chemical properties respectively. Table 1 shows that the petroleum product sample fall into the class of crude known as light crude oil hence a paraffinic base crude which will contain little or no asphaltic materials and will of course be a good source of paraffin wax, quality motor lube oils and high grade kerosene due to the viscosity and specific gravity, the petroleum sample will also yield high grade gasoline fractionated in a distillation column.

Table 1: Physicochemical properties of the crude oil sample

Samples	Specific gravity	BS[1] and W[1]%	Carbon1 residue (%)	Flash point [1] (°C)	Viscosity at 50°C	Smoke point (min) mm	API gravity	Aniline point (°C)
Crude oil	0.8705	20	2.05	2	4.25		31	
Gasoline 30-120°C	0.7850		2.03	<25	0.72		47.2	33
Kerosene 120-250°C	0.8212	0.0	2.02	55	1.36	22.5	40.8	50
Light gas oil 250 – 300	0.8503	0.0	2.0	88	3.38		34.9	66
Gas oil 300 and above	0.8573	0.0	1.0	92	3.77		33.6	68

Table 2 shows that the sample contains little or no sulphur as seen from the hydrogen sulphide content hence is accordingly referred to as sweet crude as against sour crude oil which contains substantial amount of sulphur. The sample is classed as 'sweet' as it will pose less environmental problem as well as less refining costs as there will be little or no catalyst poisoning in the fluid bed or fixed bed catalytic reactors (catalyst deactivation). Sweet product also commands higher prizes in the international market.

Table 2: Chemical properties

Dissolved solids

Cations	Mg/l	pH	8.8
Sodium Na^{2+}	1796	Specific gravity 60/60	1.008
Calcium Ca^{2+}	Nil	Conductivity	8.77 ohm meter
Magnesium mg^{2+}	Nil	Sulphide is H_2S	Nil
Barium Ba^{2+}	Nil	Turbidity	3.6 NTU
Iron fe^{2+}	0.2	Dissolved O_2	Nil
Hardness	100	Temperature (°C)	38.5
Anions		Heavy metals	
Chloride Cl^-	1512	Cadmium, Cd	0.0mg/l
Sulphate SO_4^{2-}	Nil	Copper, Cu	0.0mg/l
Carbonate, CO_3^{2-}	144.5	Zinc, Zn	0.01mg/l
Bicarbonate, HCO_3	1866	Potassium, K	36mg/l
Total dissolved solids (TDS)	5319mg/l	Total dissolved solids by evaporation	5976mg/l
Total suspended solid (TSS)	30	Chemical oxygen demand (COD)	60mg/l
Odour	Unobjectionable	Biochemical oxygen demand (BOD)	15mg/l
Colour	Brownish black	Oil and grease content	10mg/l
Cu^{2+}	0.0	Salinity as chloride	1512

Zn^{2+}	0.01		
Cr^{2+}	0.05		
Pb^{2+}	0.08		

IV. CONCLUSION

The laboratory assay or result show the product sample to be highly alkaline with (PH 8.8) and negligible hydrogen sulphide presence, hence will pose less corrosion and environmental problems, scaling and formation of fouls in refinery equipment. The results also show the presence of heavy metals in small amount and a specific gravity of 0.8705 indicating a paraffinic product sample which will yield desirable refined products.

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ABBREVIATIONS AND MEANINGS

OML	Oil mining license
Stooip	Stock tank original oil in place
BOPD	Barrels of oil per day
LNG	Liquefied natural gas
LGA	Liquefied Petroleum gas
BS & W	Basic Sediment and water
API°	American Petroleum Institute
TBX	Toluene, Benzene and Xylene
DESALTING	Removal of Salt from crude oil
AAS	Atomic Absorption spectrophotometer
GLC	Gas liquid chromatographic column

FTIR	Fourier Transform Infrared Spectrophotometer
ASTM	American society for testing materials
SAE	Society of Automotive Engineers
SPE	Society of Petroleum Engineers
NTU	Nephelometric Turbidity Unit
NGL	Natural gas liquids
HGO	Heavy gas oil
CDU	Crude Distillation unit
MMSCFD	Million Standard Cubic feet per day
M^3SCFD	Billion Standard cubic feet per day
M^4 SCFD	Trillion Standard cubic feet per day
UAE	United Arab Emirates
DTA	Differential Thermal Analyzer
TGA	Thermo gravimetric Analyzer