© A Publication of the Centre for Research and Development (CERAD), The Federal University of Technology, Akure, Nigeria (www.jost.futa.edu.ng)

JOST 2021

Determining the Relationship between Specific Gravity (60°C) and Kinematic Viscosity of the Crude Oil Samples in Selected Nigerian Oilfields

Ebikapaye Peretomode

Department of Petroleum and Gas Engineering, Delta State University, Abraka, (Oleh Campus), Delta State, Nigeria.

Corresponding Author: Ebikapaye, P.: peretomodejeffery7@gmail.com

ABSTRACT: Crude oils from different geological location have always differed from one another and this has been a pillar statement in the oil and gas industry. Crude found in same geographical region (Niger Delta region) share some varying behavior relative to each other. This study investigates the relationship between specific gravity and kinematic viscosity of the crude oil samples in selected Nigerian oilfields. Results obtained from using ASTM D 1298 and ASTM D 445 in determining the relationship between specific gravity and kinematic viscosity of the crude oil samples in the selected Nigerian oilfields shows that an increase in API gravity records lower kinematic viscosity and vice versa. The Kinematic viscosity decreases with an increase in temperature and an increase in specific gravity shows an increase in mean average boiling point since an increase in specific gravity increases the molecular weight. The result of this work has demonstrated and laid a clear understanding of the relationship between chemical properties such as boiling points, specific gravity and kinematic viscosity.

Keywords: Specific gravity; crude oil blends; composition; properties

JoST. 2021. 11(2): 10-14

Accepted for Publication, September 22, 2021

INTRODUCTION

Petroleum fluids are complex fluids, normally of undefined composition that require a characterization procedure to obtain relevant information (Abdulkareem e*t. al.,* 2006). Crude oil samples obtained from different oil fields vary both in physical and chemical properties. This is as a result of different proportions of the various molecular types, sizes of hydrocarbons and other elemental constituents in the crude mix (Oderinde 1984). The increasing chemical utilization of crude oils and petroleum product calls for a better knowledge of the composition, structure and properties of their fractions (Odebunmi et. al., 2007). Parameters often determined in crude oil include: Density, API gravity, Pour point, Kinematic Viscosity, Water content (%) Salt content (%) Sulphur content (%), Asphaltene (%), ASTM Distillation cracking point as well as Metal/mineral contents. These important parameters are used to specify and to classify crude oil blends (Oyekunle *et. al.,* 2004).

In Nigeria, crude oil is produced mainly in the Niger delta region where the oil fields are characterized by multiple sand reservoirs of tertiary sedimentary deposits. Consequently, on the out fields, the wells exist as pockets of crude possessing a unique character. Therefore, for convenience of commerce, economics and processing; crude oils are often blended into a mix that has a unique character. Presently, there are more than fourteen commercially available crude oil blends in Nigeria. These include: Bonny light, bonny medium, Qua Iboe light, Escravos light, Brass Blend, Pennington light, Focados blends, Amenam blend, Oso condensate, Yoho light, Erha blend, Bonga blends and Agbami light (NNPC, 2002).

It is pertinent to identify the chemical nature of crude as knowledge in the upstream and downstream operations saves petroleum engineers cost and time in reserve estimation, crude recoverability and in the refining process.

The objective of this paper is to determine the relationship between Specific gravity at 60ºC and Kinematic viscosity of the crude samples in selected Nigerian oilfields.

MATERIALS AND METHOD

The properties of crude such as specific gravity and kinematic viscosity was determined using ASTM D 1298 and ASTM D 445.

Crude Oil

Five Niger Delta crude were sampled from major terminals. Two were supplied from NNPC and others from quality laboratories in Lagos. These samples have been carefully stored and sealed prior to individual collections to maintain its quality and preserved in a dry environment. The sampling was done in accordance to ASTM D4057. Below is a table showing crude source and respective terminals.

Table 1: Niger Delta Crude Oil and Terminal

Crude	Terminal	Platform
Agbami Light	Agbami	FPSO
Bonga Blend	Bonga	FPSO
Ebok	Ebok	FSO
Usan	Usan	FPSO
Akpo Blend	Akpo	FPSO

Specific Gravity Measurement Using Hydrometer

The density of the crude oil was determined using a hydrometer setup that complies with the ASTM D1298. All glass wares were previously washed with distilled water and carefully air dried to pristine state. The hydrometer available is a two-way reading hydrometer that is calibrated to read-off both density of liquids API gravity. Therefore, both forms were gotten off without conversion.

Experimental Procedure for Specific Gravity

Distilled water is poured into one well-sized volumetric cylinder and samples of crude to be measured were poured into another. The hydrometer is carefully immersed into the water to kick start the measurement of liquids. This is done to calibrate and ascertain the accuracy of the Hydrometer to be used. After successful calibration, crude sample density/API gravity measurement was commenced prior to sample temperature measurement.

The hydrometer was placed into the cylinder containing the oil and then gradually submerged into the crude avoiding contact between the cylinder and the hydrometer to prevent breakage. The hydrometer is allowed to submerge and emerge till the hydrometer remains constant in one position. Reading of the hydrometer was done from a leveled eye view with meniscus error avoided, then density and API gravity is read off and recorded, afterward recorded value was corrected to reference temperature of 60ºF(15ºC).

Kinematic Viscosity Measurement Using an Auto Viscometer

Kinematic Viscosity is an important property of crude and this can be determined using a viscometer. The SpectroVISC Q300 S-Auto Viscometer is used to determine this property with a high accuracy and conforms to ASTM D445. Its thermostatic bath has control column. It enables the measurement of four crudes simultaneously since it has four viscometer tubes that works independently of one another and has optical sensors at start and ending of each tube and a very precise meniscus detection.

Laboratory glass wares

Table 2: ASTM Methods and Equipment

ASTM	Test	Equipment/apparatus
ASTM D 1298	API Gravity, Specific Gravity	Hydrometer Setup
ASTM D 445	Kinematic Viscosity @40ºC and 50ºC	SpectroVISC Q300 Auto-Viscometer

Experimental Procedure for Kinematic Viscosity

Procedurally, the machine was confirmed to be in a ready state by a laboratory technologist. The bath was heated to a required temperature (50°C and 40°C for this project) and 0.4ml of crude sample injected into the patented tubes. As sample moves down the tube, it was heated to bath temperature by high conductive nature of the system before it gets to the horizontal arm of the tubes. The measurement started as soon as the optical sensor sensed the warmed-up sample and measurement terminated as soon as the sample hits the second optical sensor. After the second sensing, the kinematic viscosity result was displayed on the system LCD and recorded. The measurement is done in twos because the other two patent glasses were faulty and a cleaning process takes place and the next samples are injected for measurements.

RESULTS AND DISCUSSION

Crude oils from different geological location have always differed from one another and this has been a pillar statement in the oil and gas industry. Crude found in same geographical regions (Niger Delta region for this project) share some varying behavior relative to each other. On a visual projection at crude property's, the API gravity (i.e. the specific gravity) appears to be the most crucial and important property of crude oil that commands its market value and commercial stamina in the world market.

From Figure 1, as shown above, the values of the selected crude API Gravity range from 18.65° to 47.45° and respective kinematic viscosity values ranging from 35.45cSt to 1.2cSt. This is why Ebok crude sulfur content is higher than the other five. Agbami Light is the least sulfur deposited of them all. The percentage of sulfur shows an increasing trend to specific gravity.

The relationship as observed in the figure succinctly shows an inverse relation. The kinematic viscosity decreases as API Gravity increases.

The sulfur content of crude follows a decreasing relationship with its corresponding increase in API gravity as observed in the selected Niger Delta crude in figure 2. This is in confirmation with Ekwere, D (1991), where he sated an inverse relationship between API Gravity and sulfur content.

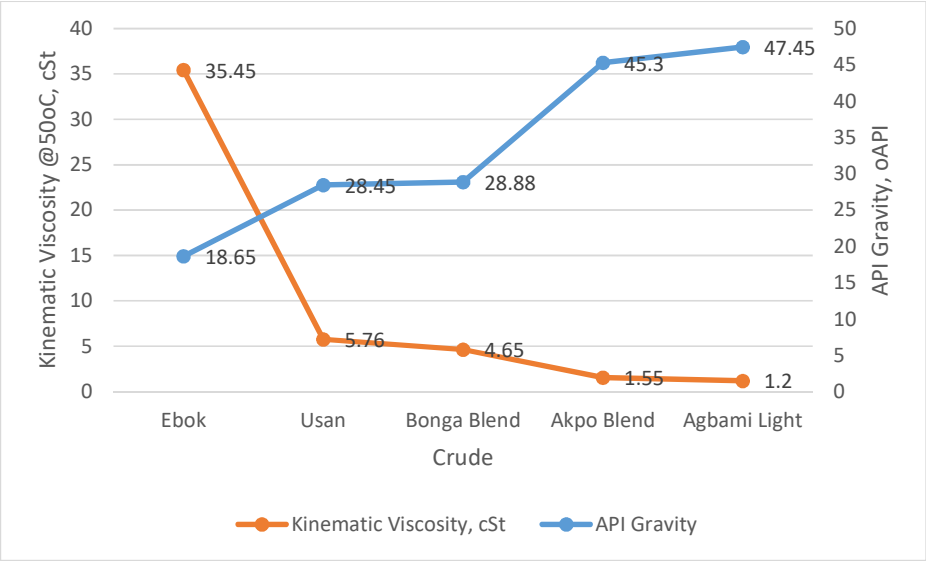

Figure 1: Plot showing relationship between API gravity and kinematic viscosity

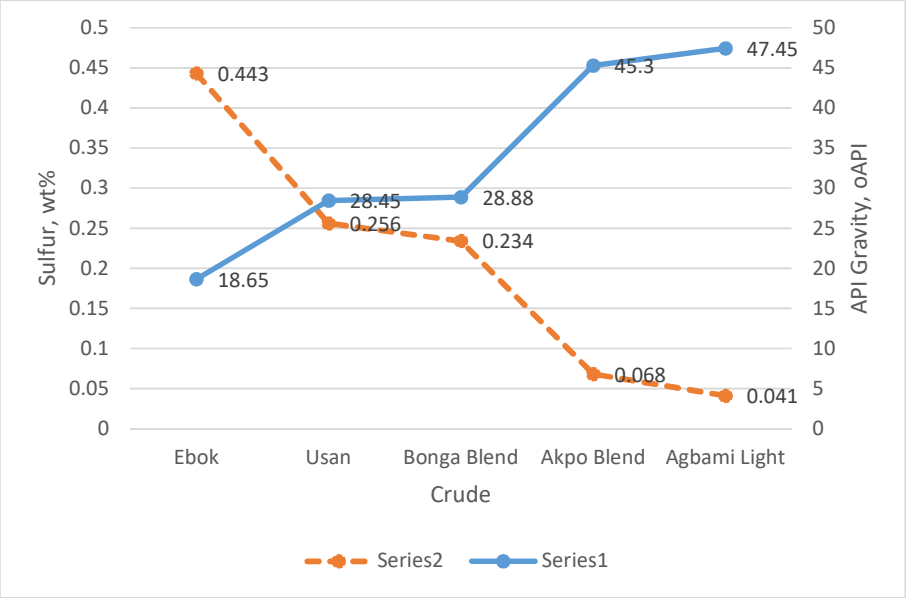

Figure 2: Plot showing the relation between API gravity and sulfur content

It has been found that, areas where heavy crude oil samples are reportedly in abundance are also associated with high deposits of sulfuric rocks and vice versa (USEIA, 2011) and this is observed in the five samples. This is why Ebok crude sulfur content is higher than the other five. Agbami Light is the least sulfur deposited of them all. The percentage of sulfur shows an increasing trend to specific gravity.

CONCLUSION

As clearly seen in Table 1, crude property values and measurement of the Niger Delta crude blends in relation to one another show increasing API gravity records lower kinematic viscosity and vice versa. The Kinematic viscosity decreases as temperature increase while an increase in specific gravity shows an increase in molecular weight. Also increase in specific gravity shows an increase in mean average boiling point The lighter crude such as Akpo blends and Agbami light, are relatively susceptible to easy flow through porous media and production tube up to storage due to their relatively low kinematic viscosity values, hence do not require much intervention for proper transportation and production. Unlike the light crude, Bonga blend, Usan, and Ebok blend which is the heaviest among the bunch has lower fluid flow. This experimental work results and analysis has demonstrated the diverse compositional make-up of crude and has laid a clear understanding of the retaliations between chemical properties such as boiling points, specific gravity, kinematic viscosity,

REFERENCES

Abdulkareem, A.S and Kovo, A.S (2006). Simulation of the Viscosity of Different Nigerian Crude Oil. Leonardo Journal of Sciences. 8: 7-12.

ASTM D1298 – 99 Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.

ASTM D341 – 03 Standard Test Method for Viscosity-Temperature Charts for Liquid Petroleum Products1.

Ekwere, D (1991). Oil and Gas Operations: its Theory and Experimentation. Paper SPE

5119. Presented at the 50th Annual Fall Meeting, Houston.

Nigerian National Petroleum Corporation (2002). Research and services. Crude assay and petro-chemistry. Webmaster@nnpc-nigeria.com. Retrieved 12/07/2010.

Odebunmi, O; Adeniyi, S.A (2007). Infrared and Ultra Violet Spectrophotometric Analysis of Chromatographic Fractions of Crude Oils and Petroleum Products. Bull. Chern. Soc. Ethiop. 21(1), 135-140.

Oderinde, R.A. (1984). Studies on Nigeria's Petroleum Part 1. Varietal Differences in Vanadium and Titanium Contents. Nigerian Journal of Sciences 18:143-145.

Oyekunle, L.O; Famakin, O. A (2004). Studies of Nigerian Crudes I. Characterization of Crude Oil Mixtures. Petroleum Science and Technology. 22(5&6):665-675.

Whitson, C.H (1983). Characterizing Hydrocarbon Plus Fractions. SPE J. 23 (4): 683-694.SPE-12233PA. http://dx.doi.org/10.2118/12233-PA

USEIA-United States Energy Information Administration (2011). Short Term Energy Outlook Market Prices and Uncertainty Report Independent Statistics & Analysis.

APPENDIX

	Agbami Light	Akpo Blend	Bonga Blend	Ebok	Usan
API Gravity(°API)	47.45	45.3	28.90	18.65	28.45
Specific Gravity@15°C	0.7907	0.7978	0.8823	0.9424	0.8847
Kinematic Viscosity@40°C (cSt)	1.46	1.996	6.3	57.1	13.27
Kinematic Viscosity@50°C (cSt)	1.2	1.55	4.65	35.45	5.758
Kinematic-Viscosity@100°C (Computed)	0.674	0.723	1.880	6.577	2.270

Hydrometer Correction

$e^r = e^t/1-[23\times10^{-6}\,(t - r) - 2 \times 10^{-8}\,(t-r)^2]$

where :

e^r = hydrometer reading at the reference temperature, r °C

e^t = hydrometer reading on the hydrometer scale whose reference temperature is t °C.