PHYSICO-CHEMICAL CHARACTERISTICS OF SOME COMMERCIAL LUBRICANTS SOLD IN MARKET AROUND SURULERE, LAGOS STATE, NIGERIA

Ogbuagu, A.S. (Ph.D) and Ofuokwu, A.N.

Department of Pure and Industrial Chemistry

Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

* Author for correspondence. Mobile: +234-706-911-1945; Email: as.ogbuagu@unizik.edu.ng

ABSTRACT

Physicochemical analysis was carried out on Ten (10) different brands of motor oil, in which six (6) were monograde and four (4) multigrade lubricants. The parameters tested were Kinematic viscosity, Viscosity Index, Specific gravity, Flash point and Total base number (TBN). The test results obtained were further compared with standard ratings of the Society of Automobile Engineers (SAE). Analysis of variance (ANOVA) was determined to know if differences exited among the means of samples properties. It was observed that sample A3 had the lowest TBN of 4.21mgKOH/g, while A6 had the lowest viscosity index of 87 and did not meet the minimum statutory requirement. Sample A7, A9 and A10 had Flash point values of 218˚C, 219˚C& 218˚C respectively, which were less than the minimum requirement. Sample A_2 has the highest mean specific gravity of 0.8981at 15^0C. Most of the accessed products did not meet the minimum standard requirement.

Keywords: *Lubricants, Physico-chemical characteristics, Nigeria*

INTRODUCTION

Since the Roman era, many liquids, including water, have been used as lubricants to minimize the friction, heat, and wear between mechanical parts in contact with each other. Today, lubricating oil, or lube oil, is the most commonly used lubricant because of its wide range of possible applications [1].

Automobile lubricants are generally composed majorly of base oil (most often petroleum fractions, called mineral oils) and a minority of additives (chemicals). They can be in form of gas, liquid or solid. One of the single largest applications for lubricants, in the form of motor oil is to protect the internal combustion engines in motor vehicles and powered equipment [2]. Lubricants were at one time almost exclusively animal or vegetable oils or fat, but modern requirements in both nature and volume have made petroleum the main source of supply. The inherent problems of vegetable oils, such as poor oxidation and low-temperature properties, can be improved by attaching functional groups at the sites of unsaturation through chemical modification [3]. Fatty oils still have their uses although generally in ancillary role. The main function of a lubricant is to reduce the friction between the moving surfaces and so facilitate motion. Its second most important function is to remove heat generated in the equipment being lubricated, such as piston engine, enclosed gears and machine tools.

Modern motor engine oils are based upon oil refined from crude petroleum, synthetic oil treated with various compounds, or a mixture of one or two grades of mineral base oil and chemical additives [4]. It was also known that additives which consist of different chemical substances are included in the oil formula to extend its range of performance [5]. In bearing lubrication, a rust and oxidation inhibitive additive system is used in the oils. Also antifoam and pour point depressants may also be present. Rust and oxidation oils tend to have better water separation characteristics, which is beneficial [6].

A good lubricant helps to enhance the shelf life of the moving parts of engines, hence, the work reported in this paper shows a study of the lubricant properties such as specific gravity, viscosity index, kinematic viscosity, flash point and total base number, comparing them with standard ratings of the Society of Automobile Engineers(SAE), and statistically determining the differences in the sample properties means.

MATERIALS AND METHOD

Materials

Ten different Commercial Engine Oils designated as A1 to A10 were obtained from markets around Surulere, Lagos State, Nigeria. Sample A1 to A6 were monogrades consisting of SAE 40 and HD 40 grade oil while sample A7 to A10 were multigrades consisting of SAE 20W-50 oil grade. The instrument used in the analysis include Analytical balance (Kern 120- Germany), Kinematic viscometer bath @ 40˚C and 100˚C (Koehler, KV3000 series – USA), Canon Fenske Viscometer (Koehler, USA), Hydrometer, Open cup hot plate (Cleveland, K13900 - China), Suction device, Retort stand, Beaker and Burette.

Methods

The samples were tested for parameters such as specific gravity, viscosity index, kinematic viscosity, flash point and total base number, based on the indicated American Standard for Testing and Material (ASTM) methods, using standard and properly calibrated industrial laboratory equipment as listed above.

Specific gravity

Using ASTM D1298-85, Specific gravity was conducted by inserting a Hydrometer into a measuring cylinder containing a 900mL of oil and a thermometer to check temperature. It was then allowed to stand for 10mins after which the temperature was recorded. The hydrometer numbers with the temperature recorded were used to obtain the specific gravity @ 15˚C by checking with a standard measuring table.

Kinematic viscosity

Using ASTM D0445, Kinematic Viscosity was determined by using a *Canon fenske* viscometer, in which oil was drawn into the smaller bulb by suction, and then allowed to flow down through the capillary into the upper bulb. The marks above and below indicate a known volume. The times taken for the level of the fluid to pass between these marks were proportional to the kinematic viscosity. This was accessed by placing the viscometer into a controlled kinematic viscometer bath, after the kinematic viscosity has been determined, viscosity index was checked using a viscosity index table.

Flash Point

Using ASTM D92-90, Flash Point was conducted by using the open cup hot plate in which 250mL of oil was measured and taken into the open cup and a small flame was passed through the open cup at regular times. The temperatures at which a flash appeared on the surface of the samples were recorded to be the flash point.

Total base number.

Using ASTM 2896-15, Total Base Number was ascertained by introducing 5.0g of the sample into a beaker, 10ml of toluene; 25ml of Glacial acetic acid, 2-3 drop of p-napthtolbenzene indicator solution were added to the beaker. This was thoroughly mixed and titrated with standard 0.1N perchloric acid solution until a bright green end point was formed. The quantity of 0.1N perchloric acid solution used was recorded. A blank solution consisting of a mixture of 10ml of Toluene, 25mL of Glacial acetic acid and 2-3 drops of indicator solution was also titrated with 0.1N of perchloric acid. The quantity of acid used was recorded. Total Base Number was calculated using the formula below:

$$\text{TBN (mg KOH/g sample)} = \frac{(A-B) \times N \times K}{W}$$

Where A is Titre value
B is Blanck value
N is Normality of perchloric acid
W is Weight of sample
K is Constant (56.1)

The data obtained were subjected to Analysis of Variance (ANOVA) as well as multiple comparism with harmonic mean at 95% confidence level.

RESULTS AND DISCUSSION

The results obtained from the analysis of these commercial lubricating oil samples are given in Table 8.2.2.1.

Table 8.2.2.1: Physico-chemical parameters of oil samples

Characteristics	Appearance	Specific gravity at 15˚C	Kinematic Viscosity		Viscosity Index (VI) (min)	Total Base Number mgKOH/g(min)	Flash point, COC˚C (min)
			at 40˚C cst (mm^2/sec)	at 100˚C cst (mm^2/sec)			
A1	Bright and Clear	0.8958	154.58	14.86	95.00	5.68	230.00
A2	Bright and Clear	0.8981	151.61	14.58	94.00	5.63	254.00
A3	Bright and Clear	0.8898	153.26	15.45	102.00	4.21	243.00
A4	Bright and Clear	0.8935	154.16	14.90	96.00	5.14	239.00
A5	Bright and Clear	0.8968	155.12	15.04	97.00	5.23	239.00
A6	Bright and Clear	0.8871	179.03	15.58	87.00	5.20	240.00
A7	Bright and Clear	0.8954	124.40	13.63	106.00.	7.26	218.00
A8	Bright and Clear	0.8825	161.61	18.35	128.00.	6.69	220.00
A9	Bright and Clear	0.8881	174.30	19.61	180.00	9.43	219.00
A10	Bright and Clear	0.8954	124.40	13.53	106.00	7.26	218.00

Specific gravity: The value of specific gravity of each of the commercial oils presented in Table 8.2.2.1 falls within the range of the specific gravity of mineral oil, which is from 0.85 to 0.90 [7], the standard for SAE 40 and HD 40 engine oil specifies a minimum value of 0.88 SG at 15°C while that of SAE 20W-50 engine oil specifies a minimum value of 0.885 SG at 15°C. Hence, the values obtained meet the requirements mentioned and a few including A1, A2, A4, A5, A7 and A10 are closer to the upper limit, which means that these commercial oils will require the use of high powered pumps for good flow and circulation within the engine.

Kinematic viscosity: The kinematic viscosities (KV) at 100°C of the samples A1-A6 were within the SAE 40 range (which is 12.5 cSt to 16.3 cSt, while the KV at 40°C was found to be highest (179.03) in sample A6) for monograde oils. For multigrade oils, samples A8 & A9 were within the SAE 20W-50 standard (which is 16.3 cSt to 21.9 cSt, while KV at 40°C was found to be highest (174.03) in sample A9), however sample A7 (13.63)& A10 (13.53) did not meet up to the standard at 100°C. Sample A7 & A10 (having 124.40 cSt at 40°C), followed by sample A2 (having 151.61 cSt at 40°C), then sample A3 (having 153.86 cSt at 40°C) are the most preferred from the viscosity at 40°C point of view, because oil with reduced viscosity, especially at low temperatures can maintain good hydrodynamic oil film. Looking at the viscosities of the oil samples at 100°C, sample A9 offers better separation between interface asperities within the regions of high temperatures compared to the rest, because it has the highest viscosity at this temperature region [8].

Viscosity index (VI): As shown in Table 8.2.2.1, from the first six tested samples, the viscosity index of A2 and A6, did not meet up to the minimum statutory requirement of 95 for monograde, also, A7 and A10 did not meet up to the minimum statutory requirement of 120 for multigrade lube oil. This implies that no or less efficient VI improver might have been used in the formulation; or that the base oil is of such a low quality that it lacks solvency to dissolve the VI supplement used in the formulation [9]. This kind of mediocre viscosity index cannot meet up with the rising demands on lubricating oils by new generation combustion engines, because the viscosity will be too low at high temperatures (above 120°C) giving room for asperity contacts between tribological pairs. Also, sample A3 monograde and A9 multigrade both have exceptionally high VI, implying that it must have been treated with high performance, and good dose of VI improver(s). Although, oil treated with high dose of VI improvers may exhibit susceptibility to mechanical shearing [10].

Flash point: From Figure 8.2.2.1, it can be observed that the flash points of all the oil samples meets the minimum specified standard for both SAE 40 and SAE 20W-50 oils of 220°C except for A7, A9 & A10 which are less than the minimum specified reading 218˚C, 219˚C and 218˚C respectively. Those above 220°C implies that these oils have relatively low volatility and can be run safely in internal combustion engines [11]. The low volatility equally means lower oil consumption (i.e. engine oil getting reduced in volume in the course of its utilization) rate [11], and lower evaporation loss. The differences in their flash points should be majorly base stocks related.

Total base number (TBN): The TBN number reveals the same information with the Total Acid Number (TAN). The TBN of new crankcase oil normally ranges from 5 to 15g KOH/mg [12]. According to SAE standards, TBN for SAE 40 grade minimum specification is 5 while that of SAE 20W-50 is 6.5. From the reported result in Figure 8.2.2.2, all of the oil samples meet the minimum requirement except sample A3 which will tend to deplete faster than others in terms of Alkalinity content. Sample A3 has the lowest TBN which could be that they may have been blended with additive packages which have very poor or no corrosion/rust inhibitors, and dispersants. Another reason may be the use of wrong proportion and/or combinations of rust inhibitors and antiwear additives which could raise the acidity of the oil thereby reducing their TBN. It should be noted that oil with TBN number below 3 g KOH/mg is recommended for a change [12] because it could expose the engine to very early corrosion and rust, and the oil to early or faster oxidation if not changed.

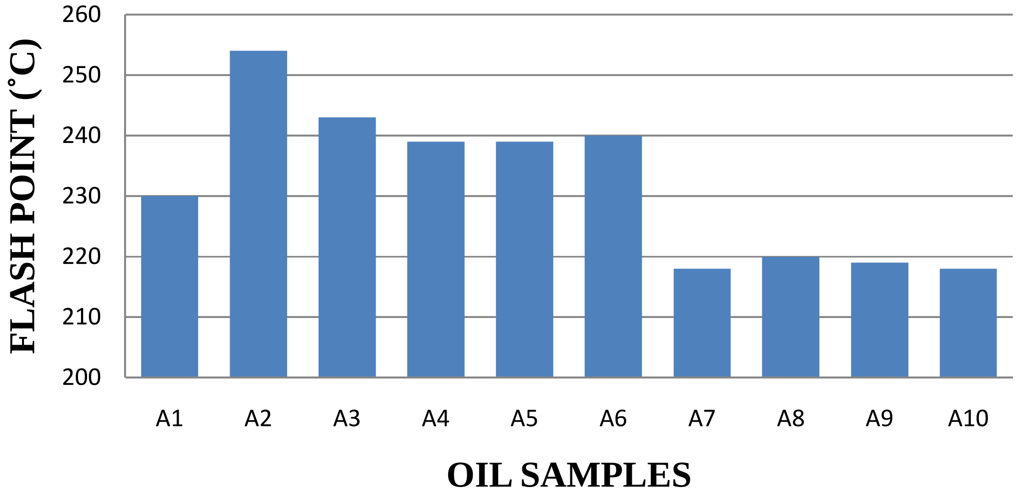

Figure 8.2.2.1: Flash point of the oil samples

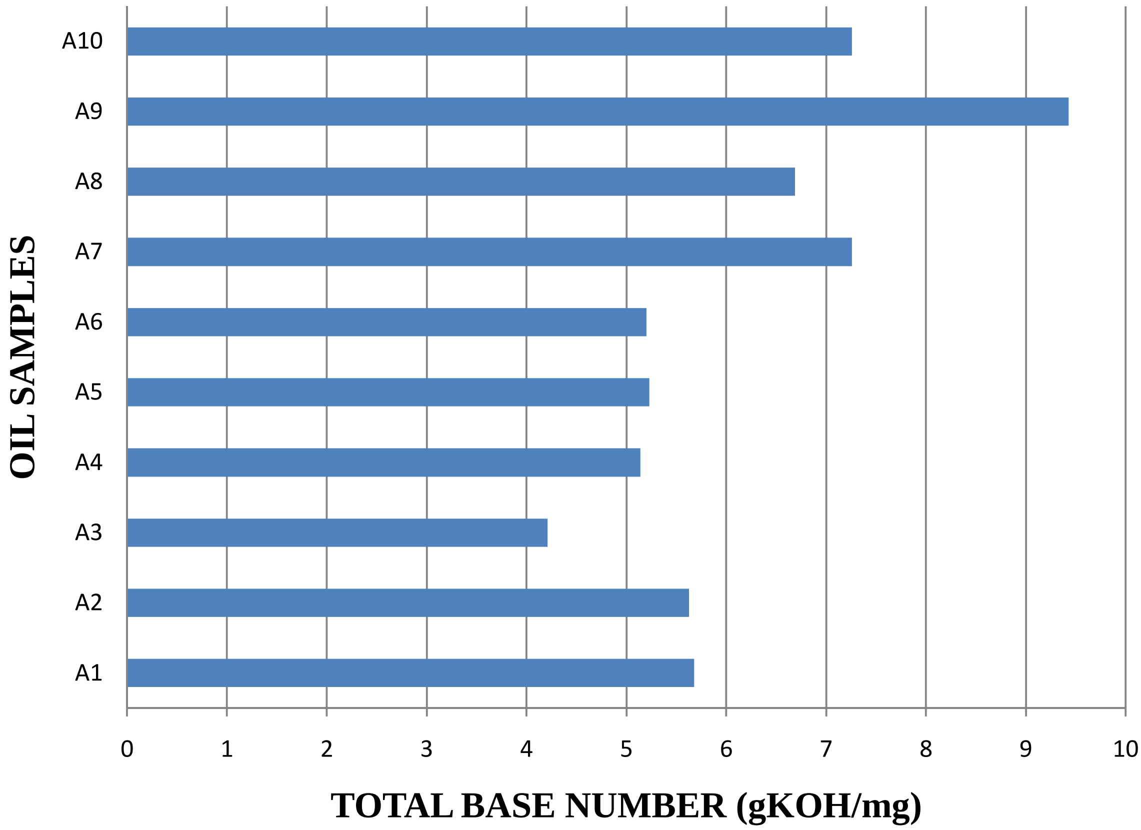

Figure 8.2.2.2: Total Base Number of the oil samples

ANOVA summaries

Table 8.2.2.2 shows ANOVA values of mean specific gravity.

Table 8.2.2.2: Mean specific gravity

Spesific gravity					
	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between groups	0.001	9	0.000	55.555	.000
Within groups	0.000	20	0.000		
Total	0.001	29			

Table 8.2.2.3 shows ANOVA values of mean kinematic viscosity at 40^{o}C

Table 8.2.2.3: Mean kinematic viscosity at 40^{o}C

Kinematic viscosity at 40^{0}C					
	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between Groups	7087.772	9	787.530	71.113	.000
Within Groups	221.486	20	11.074		
Total	7309.258	29			

Table 8.2.2.4 shows ANOVA values of mean kinematic viscosity at 100^{o}C

Table 8.2.2.4: Mean kinematic viscosity at 100^{o}C

Kinematic viscosity at 100^{o}C					
	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between Groups	48.226	9	5.358	10.705	.000
Within Groups	10.011	20	.501		
Total	58.238	29			

Table 8.2.2.5 shows ANOVA values for mean viscosity index

Table 8.2.2.5: Mean viscosity index

Viscosity index					
	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between Groups	3306.300	9	367.367	18.839	.000
Within Groups	390.000	20	19.500		
Total	3696.300	29			

Table Table 8.2.2.6: shows ANOVA Table values for mean flash point

Table Table 8.2.2.6: ANOVA Table values for mean flash point

Flash point					
	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between Groups	4481.200	9	497.911	25.754	.000
Within Groups	386.667	20	19.333		
Total	4867.867	29			

Table Table 8.2.2.7 shows ANOVA Table values for mean Total Base Number

Table Table 8.2.2.7: ANOVA Table values for mean Total Base Number

Total Base Number					
	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between Groups	61.598	9	6.844	122.154	.000
Within Groups	1.121	20	.056		
Total	62.719	29			

From the statistical analysis shown in Figures 8.2.2.1-2 and Table 8.2.2.2-7, t-test were used to test group variance against a null hypothesis, and is often used to determine whether any group of trials differs significantly from an expected value. Hypothetically, null hypothesis, H_o indicate the mean sample properties of the different oil samples is equal alternative hypothesis H_1: Not all the means are equal.

Significance level, $\alpha = 0.05$

From the decision Rule, we reject H_o if p-value is less than the significant level (α) and accept $H_{1.}$ The p-value 0.00 of each samples properties means obtained were less than α which depicts that they are significantly different at 0.05 level of significance.

CONCLUSION

This work has shown that not all commercial engine oils sold in Nigeria lubricant market conform to SAE standards. There are associated risks, including negative impacts on engine durability, especially if one sticks to one of the defective products.

RECOMMENDATION

Based on these observations and the conclusions which were drawn, it isrecommended that a closer monitoring and enforcement capacity for the quality regulating bodies are to be ensured so as to avoid products which do not conform to standards to be in Nigeria market.

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