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Research Article

Comparative Assessment of the Physicochemical Properties of Some Commercially and Locally Blended Engine Oils within Awka Metropolis

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Abstract

The physicochemical properties of eight (8) different samples of locally blended engine oil and two (2) commercially made engine oil within Awka metropolis, Anambra State were analyzed in accordance with the American Society for Testing and Materials (ASTM) standards. The result obtained showed that there was a significant difference in the Kinematic Viscosity at 40°C while at 100°C there was no significant difference for all the samples analyzed. The range of the kinematic Viscosity at 40°C was 143.21 cst - 159.11 cst while at 100°C the Kinematic Viscosity range reduced to 13.30 cst - 18.41 cst. Samples D and E had the highest Viscosity Index of 128 and 129 respectively among the locally blended oil samples. Similar trend was also observed for the Specific Gravity of the oil with a standard deviation range of 0.0007- 0.0042. The Flash Point of the locally blended oil samples were below standards except for sample G (213°C), while the commercially made oil samples had Flash Points 225°C and 233°C for R1 and R2 respectively which were above the standard range of 204°C - 220°C. All the oil samples had values of Total Acid Number (0.049 - 0.209 mgKOH/g) within the standard value and the moisture content results showed that only five samples (A, B, C, F and G) met the requirement. The ANOVA analysis of all the properties for the samples at 95% confidence level showed that there was significant difference in all the properties among the samples except in the kinematic Viscosity at 100°C. The research revealed that the commercially made oils were of better grade than the locally blended oils.

Keywords: Engine Oil; Blended Engine Oil; Viscosity; Flashpoint; Viscosity Index; Moisture Content; Total Acid Number

Introduction

Engine oil is any of the various substances comprising base oils enhanced with additives used for lubrication of internal combustion Engines with the main function of reducing friction and wear on moving parts and clean the engine from sludge and varnish [1]. A commercially made engine oil is thus an engine oil produced and distributed in large quantities by a registered company under the supervision of a quality Control body while locally blended Engine oil are those produced in smaller quantities by non-registered firm and not under the supervision of any quality control body. Auto mobility being an important factor in the socio economic life of man and engine oil being the most effective lubricant in automobiles has attracted researcher's interest [2,8]. Modern motor engine oils are based upon oil refined from petroleum (mineral base oil), synthetic oil treated with various compounds or a mixture of one or more grades of mineral based oil and chemical Additives [2,5]. Hence, typical engine oil consists of 70 - 90% base oil and 10 - 30% Additives [3]. These additives which are proven chemical s or materials when incorporated in base oils supplement their natural characteristics and improve their field service performance in existing application or broaden their areas of utility [4,9]. Anti-oxidants decreases oil oxidation with the secondary effect of reducing corrosion of certain types of sensitive bearing materials. Viscosity index improvers increase the viscosity index because the higher the viscosity index, the wider the range over which the engine oil will function effectively [5-10]. The quality of engine oils is thus not only determined through purification and manufacturing processes but also through the addition of certain chemical compounds or additive agents. Hence, without these proved chemical additives incorporated in the lubricant, the present high mechanical output and long service life of machine would be impossible [6,7]. There are various brands of engine oils in the market, the choice which is left to the users' discretion. Therefore, the objective of this work is to study physicochemical qualities of some automobile engine oils in the market [11,12]. The need to know the quality of locally blended engine oil as a guide to knowing which choice is to be made for our generator set I pass my neighbor necessitate this work.

Materials and Methods

The samples of locally blended engine oil were selected from eight (8) different areas within Awka metropolis, Anambra State of Nigeria and two commercially made engine oils one mono grade and the other multi grade were also selected. The eight areas were Ifite, Aroma, Okpuno, Unizik Junction, Kwata, Amawbia, Ekeawka and Amaenyi coded A, B, C, D, E, F, G and H respectively. The two commercially made engine oils were coded R1 and R2.

The physicochemical properties of the engine oil examined in this study and their test methods in line with American Society for

Testing and Material (ASTM) include Kinematic Viscosity (ASTM D445), Flash point (ASTM D87), Total Acid Number (ASTM D974), Specific Gravity (ASTM D1298) and Moisture Content (ASTM D6304). Among others, the Kinematic Viscosity is the most important analysis carried out on engine oil

Analysis of Variance (ANOVA) using SPSS Computer package version 20 was also used to statistically analyze the results.

Determination of Kinematic Viscosity (ASTM D445): The viscosity water bath was first filled with water, heated to the desired temperature (40^{0}C or 100^{0}C), and maintained at that temperature. The viscometer was filled to the mark with the sample, corked, inserted into the water bath and left for about an hour and 30 minutes to attain thermal equilibrium with the temperature of the water in the bath. When this was achieved, the sample was drawn up to the orifice of the viscometer using pipette filler and the time with which it flows down recorded. This experiment was repeated twice and the average result recorded. This result was then multiplied with the constant of the viscometers depending on the series and the final result recorded in Centistokes (cst). The results obtained were then used to calculate the Viscosity Index.

Kinematic viscosity (cst) = time of flow (sec) × Viscometer constant

Determination of Specific Gravity (ASTM D1298): A 500 ml measuring cylinder was rinsed with the sample to avoid contamination by the previous sample analyzed. The sample was poured into the measuring cylinder and a hydrometer of range 0.85 - 0.95 gently dropped into the sample allowing it to become stable. The density reading was then taken from the point where the sample cuts the hydrometer and the hydrometer removed. The sample was then stirred with a thermometer immediately after removing the hydrometer and the temperature of the sample taken. An international reference standard table was used to correct the density at the observed temperature to Specific Gravity@ 15^{0}C. t

Determination of Flash Point (ASTM D87): The sample cup of the flash point tester was cleaned and dried. The sample was made homogenous by shaking and then filled to the mark of the sample cup. A thermometer was inserted into the cup, the heater turned on, and the test flame lighted and adjusted. The sample was monitored at intervals of 3^{o}C rise in temperature from 28^{o}C to 30^{o}C below the expected flash point and the observed flash point recorded in Celsius.

Determination of Moisture Content (ASTM D6304): The Karl Fischer equipment used for the titration was switched on and 30 ml of the titration solvent poured into the titration flask using a pipette. The equipment was then conditioned severally to remove any available moisture which may interfere with the result. A syringe was weighed, used to collect a sample of the engine oil, and both the syringe with the sample weighed. The sample collected was transferred into the titration flask and titrated against the Karl Fischer reagent. The volume of the Karl Fischer reagent used for the titration was recorded as displayed on the screen and the moisture content in ppm calculated.

$$\text{Moisture (ppm)} = \frac{\text{vol. of Karl Fischer reagent} \times 3.5714 \times 1000}{\text{Weight of sample}}$$

Normality of Karl Fischer reagent = 3.5714

Determination of Total Acid Number (TAN): 20g of the engine oil was weighed in a 250 ml Erlenmeyer flask. 100ml of the titration solvent and 0.5 ml p-naphtholbenzein indicator was also added to the weighed engine oil. On the addition of p-naphtholbenzein, the solution developed a yellow-orange color. The solution was then swirled to dissolve the sample and titrated immediately at room temperature with standardized acidic potassium hydroxide (KOH). Titration continued till a green-brown color developed and recorded as the end point if the color persists for 15seconds and the TAN calculated.

$$\text{TAN (mg KOH/g sample)} = \frac{(A-B) \times N \times 56.1}{W}$$

Where: A = Titre value

B = Blank value

N = Normality of KOH = 0.0874

W = Weight of sample

Results and Discussion

The results of the physicochemical analysis of the oil samples are shown in the tables below. The recorded results are the average of 2 - 3 tests.

The results of the Kinematic Viscosities at 100^{o}C and 40^{o}C as shown in table 1 revealed that there was a significant reduction in the viscosity of the oil @ 100^{o}C. This is because as the temperature increases, the time of interaction between neighboring molecules decreases as a result of the increased average Kinetic Energy of the molecules, consequently leading to decrease in Viscosity. The results of the Kinematic Viscosity @ 100^{o}C showed that samples A, B, C and H, were within the range of single grade engine oil which is 9.30 - 16.30 cst, while samples D, E and F were within the range of multi grade engine oil of 16.30 - 21.90 cst. In view of this, samples A, B, C and H, will protect the engine at one temperature, either hot or cold, while samples D, E and F, will protect the engine at more than one temperature, both hot and cold. The Kinematic viscosities of the commercial samples R1 and R2 which are single-grade and multi-grade respectively showed that they were well graded. Sample G with viscosity of 13.30 fell below the standard. Thus, this oil when used in motor engines will not lubricate the engine effectively due to low viscosity. From the ANOVA analysis, the probability value for kinematic viscosity @ 40^{o}C which is 0.00 shows that there is significant statistical difference between the kinematic viscosities of the sample while at 100^{o}C, the probability value is 0.388 indicating no significant statistical difference.

The result of Viscosity Index showed that samples A, B, C and H met the API's requirement of 95 (minutes) for single grade oils while samples D, E and F fell within the range of minimum of 120 for multi grade. The results of samples R1 and R2 show that they are well graded. Thus, these samples A, B, C, D, E, F, R1 and R2 will resist thinning at high temperatures and thickening at low temperatures while sample G with Viscosity Index of 84 which does not meet the requirements for both single grade and multi grade will not resist thinning at high temperatures and thickening at low temperatures due to its low viscosity Index which may be as a result of inadequate addition of viscosity index improvers.

Samples	Kinematic Viscosity		Viscosity	Specific Gravity
	@40°C (cst)	@100°C(cst)	Index	@15°C
A	157.10	15.22	97	0.8865
B	158.34	15.23	99	0.8875
C	155.70	15.26	99	0.8971
D	157.10	18.12	128	0.8960
E	159.11	18.41	129	0.8998
F	157.31	17.77	124	0.8960
G	143.21	13.30	84	0.8821
H	153.33	15.21	99	0.8755
R1	154.54	15.26	99	0.8913
R2	155.40	18.42	133	0.8961

Table 1: Results of Kinematic Viscosity @100°C and 40°C, Viscosity Index and Specific Gravity.

From figure 1 below, it was observed that the sample with the lowest kinematic viscosity @ 100°C has the lowest viscosity index while the sample with the highest kinematic viscosity @ 100°C has the highest viscosity index. It is also shown that the kinematic viscosity @ 40°C does not follow this trend. Thus, based on these results, it can be said that the Viscosity index depends mainly on the value of the kinematic viscosity @ 100°C which is the engines operating temperature and increases as the Kinematic Viscosity of the engine oil @100°C increases and vice versa.

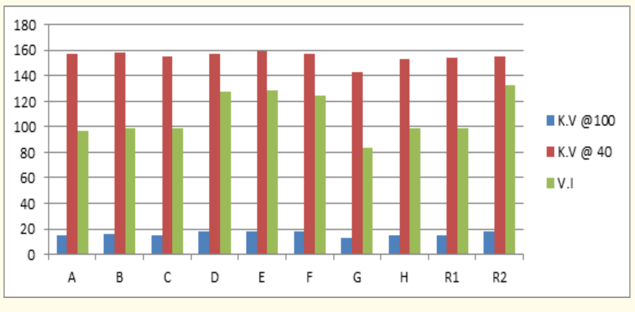

Figure 1: Chart Showing the Different Samples and their Variation in Viscosity and Viscosity Index.

From the API's requirements for specific gravity of engine oil which are minimum of 0.870, 0.880 and 0.890 for SAE30, SAE 40 and SAE 50 respectively which are single grades and minimum of 0.880 and 0.885 for SAE 15W40 and SAE 20W50 respectively which are multi grades, it was observed from table 1 that all the samples met the requirements for either single grade or multi grade engine oil and thus will have optimum pump ability and circulate better throughout the engine. The ANOVA analysis also showed that there was significant statistical difference between the samples.

The results of Flash Point as observed in table 2 below showed that only three samples which G, R1 and R2 met the API's requirements for flashpoint of 204-220°C while samples A, D, E, F and H were close to the flash point requirement for SAE 30. Samples B and C with flash point of 108°C and 125°C was below standard did not meet the requirement and thus not advisable in a service environment where a high temperature is expected and in an internal combustion engine where over 90°C is expected during abnormal condition of engine overheating. Under normal working condition, samples G, R1 and R2 satisfied the flash point requirements.

Between the samples, there is significant statistical difference based on the ANOVA analysis.

The results of the Total Acid Number showed that samples A-H (0.049 - 0.209 mgKOH/g) met the requirement of 1.0 mgKOH/g (max) for engine oils. Thus according to API, the acid levels in these samples were negligible. The results of Samples R1and R2 which were commercially made oils showed that no acid was present in the oils. These samples which have little or no amount of acid will help prevent corrosion of metallic components, reduce oxidation, reduce oil thickening and additive depletion. Therefore, they were suitable for use. From the results of the Total Acid Number obtained, the Total Base Number which is the amount of base required to neutralize the acid formed in engine oil could also be known. The results revealed that the engine oil contained reasonable amount of base to neutralize the oil but not completely for samples A, B, C, D, E, F, G and H while samples R1 and R2 contained the amount of base sufficient to neutralize all the acids formed in the oil. Therefore, the commercially made engine oil was made up of more base to neutralize the acid than the locally blended ones.

From the results and chart obtained for Moisture Content as shown in table 2 and figure 2, it was observed that the moisture content of samples A, B, C, F and G met the requirement for moisture in engine oil which is maximum of 100 ppm while sample H is slightly above the optimal amount and is referred as the caution level (101 - 500 ppm). Samples D, E, R1 and R2 are above the caution level which is referred as the warning level (> 500 ppm). At this warning level, it is required that the oil be changed because high moisture in oil leads to corrosion, acid formation, high viscosity, poor lubrication and engine overheating which consequently results to engine failure. In view of this, samples A, B, C, E and F will preserve the engine life more effectively than sample H followed by samples D, G, R1 and R2 with high moisture. The result of ANOVA analysis also showed that the engine oils have significant statistical differences.

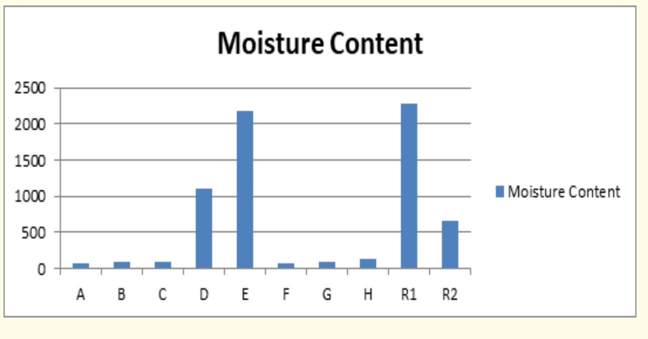

Figure 2: Chart Showing the Variations in Moisture Content of the Samples

Samples	Flash Point (^0C)	TAN (mg/KOH)	Moisture Content (ppm)
A	197	0.099	71.99
B	108	0.147	83.81
C	125	0.074	96.88
D	191	0.074	1096.94
E	200	0.209	2181.33
E	202	0.098	72.69
G	213	0.049	90.29
H	196	0.072	141.09
R1	225	Nil	2287.56
R2	233	Nil	651.62

Table 2: Results of Flashpoint, Total Acid Number and Moisture Content.

Conclusion

Summarily, this study showed that only samples A and G of the locally blended Engine oil met all the requirements for single grade, SAE 40 precisely. Other samples were found not up to the standard in one or more of the following properties: Flash Point, Pour Point and Moisture Content. These samples especially those with low flash point are not advisable for use as it is dangerous if the engine is operating at a very high temperature. The results of the commercially produced engine oil samples R1 and R2 which were already graded showed that its moisture content fell below standard. This might be due to evaporation and condensation processes as a result of the oil being in an air tight container, the weather condition as at the period of these experiments or direct absorption of moisture from the atmosphere. Thus, having met other requirements showed that these oils were well graded with R1 AND R2 being single grade (SAE 40) and multi grade (SAE 20W50) respectively and has all requirements to lubricate effectively and prevent engine failure. In accordance with the Society of Automobile Engineers (SAE) for grading engine oil on the basis on viscosity and based on the results obtained, the engine oil samples can conclusively be graded as single grade (SAE 40) for samples A, B, C, G and H and multi grade (SAE 20W50) for samples D, E and F.

Hence, In view of the above results, although some of the imperfections can be managed by motorists, it is recommended that consumers should purchase engine oils with service designation required for their engines from registered companies or fuel stations since some of these locally blended oils gotten from black markets were suspected to be simply base oils, adulterated oils or oils of inferior production to make it cheaper. It is also recommended that extensive care be taken in blending of the oils during production as some of the additives react to give an undesirable product.

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