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EXTRACTION AND LUBRICITY ASSESSMENT OF VEGETABLE OIL BLENDS IN AUTOMOBILE ENGINES

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ABSTRACT

The Automobile lubricants in use today are based on mineral oil, though chemically stable and have excellent lubricating properties. However, there have been challenges with the use of such oils; such challenges include hassle of importation, high foreign exchange rate and impacts on the environment of both fresh and used engine oil. Exhaust emissions such as carbon monoxide (CO), oxide of Nitrogen (NO_X) e.t.c from automobile engines based on mineral oils add up to planet-wide problem and climate change: the issue of global concern. This paper seeks to investigate the lubricity properties of vegetable oil blends formulated from castor and neem oil as an alternative lubricant in Automobile engines. The castor and neem seeds used for this research were oven dried at the temperature of 105^0C, and then pressed mechanically in a drum to obtain high yield oil. The oil was then filtered to remove the various unwanted particles. Each sample of the oil was investigated of tribological and physiochemical properties. Castor oil showed high viscosity value of 65.33 cps when tested at 23.6^0C, the neem oil showed viscosity value of 12.00cp at 23.6^0C while mineral oil showed 22.5cps at 23.6^0C. Among other formulated lubricants, 60%neem oil and 40%castor oil blend showed an improved property in terms of viscosity value (27.33cps at 23.6^0C), saponification value (39.830), iodine value (81.23mg/g) and specific gravity (0.933). The high flash point temperature of 327^0C from 60%neem oil and 40%castor oil blend confirms the absence of risk of fire during lubrication. The saponification test showed that castor and neem oil have 35.904 and 31.696 value respectively. From the cooling curves, it was observed that the thermal gradient of 60%neem oil and 40%castor oil blend is 3.57 which is steeper than that of castor oil (4.15), neem oil (8.43) and mineral oil (5.809). Hence, the steeper the thermal gradient of the cooling curves the shorter and faster the cooling rate. Tribology test conducted on all the formulated lubricants showed that the optimum blend has minimum Wear Scar Diameter (WSD) of 0.13mm, and therefore this is desirable during the boundary lubrication to protect the mating members from metal to metal contact. From the findings, it can be concluded that 60% neem oil and 40% castor oil blend possess the minimum requirements for an ideal lubricant and hence, it can replace the conventional mineral oil (engine oil) used in automobile engines.

KEYWORDS: Automobile engine, Castor oil, Neem oil, Mineral oil, Lubrication.

1.0 INTRODUCTION

Friction occurs when two surfaces rub each other and the force required to overcome the opposing friction force is loss between the surfaces.[1] When two or more surfaces move against each other heat is generated and this causes lost in mechanic energy, no machine can work 100 percent efficient because of this loss in energy. Hence, the need to prevent this loss and reduce friction between the mating surfaces for maximum mechanical power output. In an automobile engine, chemical energy is converted into mechanical energy by the engine and this causes parts moving against each other to produce friction.[2] To reduce this friction certain fluids may be applied to the mating surfaces to reduce losses. Such fluids which reduce friction between the mating surfaces are called lubricants. For maximum power output from automobile engines, all the mating surfaces must be lubricated.

1.1 Functions of lubricating oil

Lubricating oil performs the following functions:

(a) It saves energy by reducing friction between the moving parts

(b) It is a cooling medium for the engine piston

(c) It reduces noise between the rubbing surfaces; a highly viscous lubricant is more effective in reducing noise

(d) Lubricating oil seal a joint to make it gas-leak proof between the piston and cylinder

1.2 Properties of lubricating oil

Viscosity: This is a measure of the internal resistance of the lubricant and it is called lubricant friction. Highly viscous oils offer more resistance between the layers of the oil while sliding whereas a low viscous lubricant fails to maintain the film of the lubricant between moving parts and the parts run dry.[3]

Viscosity index: This is a number which indicates the relative resistance of a given lubricant to changes in viscosity with changes in temperature. A lubricant having a low viscosity index number has a lower resistance and its viscosity readily changes with an increase in temperature than the lubricant having a higher viscosity index number, hence, a high viscosity index lubricant is preferred.

Pour point: This is the temperature at which the lubricant stops flowing or loses its fluidity under test condition. Pour point is an important property of lubricants which are used in cold countries where atmospheric temperature reach subzero levels.

Flash point: This is the temperature at which a lubricant gives off sufficient vapours to form a combustible mixture with air. The flash point of a lubricant in an automobile engine varies from 175^0C to 250^0C. Any lubricant which has a lower flash point must not be used in automobile engine.[4]

Fire point: The temperature at which an oil continues to burn after the flammable vapour-air mixture is ignited, is termed as the fire point. The flash point is at lower temperature than fire point

Corrosiveness: The lubricating oil should not be corrosive and it should protect the surface against corrosion.

Detergency: This is the ability of a lubricant to keep a clean engine free from sludge and other deposits.

The Automobile lubricants in use today are based on mineral oil, though chemically stable and have excellent lubricating properties. However, there have been challenges associated with the use of such oils; such challenges include hassle of importation, high foreign exchange rate and impacts on the environment of both fresh and used engine oil.[5] Exhaust emissions such as carbon monoxide (CO), oxide of Nitrogen (NO_X) e.t.c from automobile engines based on mineral oil add up to planet-wide problem and climate change: the issue of global concern. Chemicals such as sulfur and chlorine contained in automobile engine oil to improve certain properties are environmentally banned chemicals because of their toxicity to the environment and man. As man is conscious about his health and environment research is on-going on alternative lubricants from biological origin that will be cost effective, environmentally friendly and sustainable as way of improving on the previous techniques and finding substitutes.[6] One out of several efforts is this attempt to formulate automobile engine oil from blend of castor oil and neem oil at minimal cost and have an equivalent or better performance over the existing engine oil.

2.0 Vegetable oil

Automobile engine oil from mineral oil origin suffers many disadvantages such as high cost, high toxicity and poor biodegradability. This disadvantages is placing vegetable oil at an advantage over the mineral oil as an automobile engine oil, the vegetable oils have many benefits to the environment because of their easily degradation by oxidation and as a lubricant, they are by their chemical structure, long chain fatty acids and are capable of provide good boundary lubrication.[7] Some of the desirable properties in vegetable oil as lubricant are: high flash point, high viscosity index number, detergency, stability, corrosion free etc.

2.1 Castor oil

Castor plant (Ricinus communis) from which castor seeds and oil are derived is grown in Nigeria especially in the southern part of the country because of the heavy presence of rain throughout the year. The plant is becoming an environmental nuisance because of its abundant and now weeds away like any ordinary weed. The recent discovery of its important in biodiesel production has increased its plantation throughout the nookies and crannies of the country.[8] reported that castor beans contain 35-55% oil by weight for high yield breed types and has one of the highest viscosities among vegetable oils. The present study is finding uses for the castor oil in lubricant industry as lubricating oil in automobile engine.

2.2 Neem oil

Neem plant (Azadirachtaindica) is commonly found in the northern part of Nigeria, which makes it easily accessible for this research. Neem oil which is derived from the Neem seed by mechanical pressing method has one of the highest saponification values which confirm its suitability for soap production and detergency. Hence, the lubricant which has the property of detergency acts to clean the engine deposits.

3.0 Statement of the problem

Automobile engine oils in use today are generally costly and have poor biodegradability [9]. The environmental impacts associated with the fresh and used engine oil include, destruction of top soil and contamination of water resources. It is known that automobile engines run on mineral oil contribute significant to air pollution which affects the qualities of human lives, plants and animals. Hence, this study seeks to investigate tribological and physiochemical properties of vegetable oil blends as an automobile engine oil

4.0 Aim and objectives

This study seeks to investigate the lubricity and physiochemical properties of vegetable oil blends as automobile engine oil

The specific objectives of the study are:

(i) To determine the viscosity of the vegetable

(ii) To determine the viscosity index, pour point, cold flow behavior, flash point, oxidation stability, density, and lubricity of the blended oil sample

(iii)To determine the various fatty acid of the individual oil

(iv)To determine the cooling properties of each oil and the blended samples

5.0 Material	**Equipment**
Castor and neem seed oil	Viscometer
Petrol and diesel engines (4- cylinder with open crankcase ventilation)	
Complete engine test bed	Grinding Machine
Conical flask graded in ml.	Gas-liquid chromatography machine
PH meter	Mechanical oil extractor
4-litre of castor	
4-litre of neem oil	Exhaust Calorimeter
Mesh sieve	Oven.
Phenol additives	Exhaust Gas analyzer Tribometer

5.1 Method

Extraction of castor seed oil

The castor seeds for this research were oven dried at temperature of 105^{0}C, and then pressed mechanically in a drum to release castor oil. The castor oil obtained has a distinct odour, viscous, pale yellow, nonvolatile and nondrying oil. Filtration was done to remove the various unwanted particles left in the extracted oil.

Extraction of neem seed oil

The neem seeds used for this study were oven dried at temperature of 105^{0}C and then feed into the oil extracting machine in mechanical pressing method. The neem oil was obtained by pressing it mechanically and collected in a drum. Thus filtration was done to remove the various unwanted particles left in the extracted oil.1kg of neem seeds produced 0.3litre of neem oil.

Plate I: Castor seed.

PlateII: Neem seed.

Plate III: Mechanical extractor. Plate IV: Grinding of neem and castor seeds into paste.

Plate V: Mechanical pressing of neem cake

Plate VI: Neem oil

Plate VII: Castor cake.

Plate VIII: Castor oil.

Table 1: Determination of physicochemical properties of the formulated lubricants.

O Oil sample (%)	Density at 26.3 °C ASTM D97	Refractive index ASTM D97	Saponifiion no. ASTM D 93	Iodine value ASTM D482	Specific gravity ASTM D93	Viscosity at 23.6°C ASTM 189	Flash point °C ASTM D92	Pour point °C ASTM D97	Emulsion stability	Acid value Mg KOH/g ASTM D95	Viscosity index
10 100Castor	4.83	1.466	194.69	88.83	0.917	12.00	329	-38	Good	8.415	50
1 100 Neem	0.945	1.465	179.23	83.50	0.961	65.33	368	-39	Excellent	17.952	53
90 90:10	0.934	1.467	39.55	86.29	0.961	21.33	367	-37	Excellent	15.708	56
80 80:20	0.923	1.468	9.817	30.46	0.927	10.00	368	-37.5	Excellent	7.854	55
70 70:30	0.892	1.468	5.049	63.45	0.929	20.67	370	-35.1	Excellent	21.879	54.5
60 60:40	0.835	1.469	39.83	81.23	0.933	27.33	375	-33	Excellent	24.123	56
50 50:50	0.795	1.470	31.416	116.75	0.937	25.33	354	-42	Excellent	22.40	50

Table 2: Heating and cooling experiment for the tested oil.

TIME(S)	TEMPERATURE (^{0}C)							
	Neem oil	Castor oil	90: 10	80: 20	70 :30	60 :40	50 :50	Eng oil
	265.83	297.34	293.6	297.7	297.85	301	284.97	205.9
120	264.52	294.77	278.33	295.14	295.14	282	280.7	193.5
180	264.18	258.7	264.56	279.44	281.9	262.16	275.13	185.23
240	232.93	223.74	256.23	266.56	271.56	235.35	268.34	174.74
300	199.37	220.74	245.56	253.23	262.66	217.78	259.16	163.22
360	166.80	185.84	234.98	242.45	251.77	202.66	247.44	155.23
420	153.82	164.36	221.34	231.66	238.66	188.67	231.55	146.72
480	145.12	153.37	207.66	219.44	219.78	162.98	222.43	132.66
540	132.53	138.29	197.56	206.98	206.78	132.66	201.88	125.13
600	126.83	129.83	183.56	195.42	195.55	115.56	188.89	112.22
660	121.74	118.26	174.23	183.38	183.38	98.56	172.22	99.79
720	195.33	103.43	158.88	172.66	172.66	88.56	164.8	89.13
780	186.82	92.63	146.43	164.77	164.77	75.95	149.45	72.45
840	178.03	84.15	138.45	155.77	155.77	63.79	132.55	63.67
900	167.33	76.23	126.34	147.83	147.83	51.28	121.13	56.34
960	158.04	63.26	116.52	134.9	134.9	43.86	98.46	48.67
1020	152.03	58.24	103.89	123.67	123.67	32.3	83.77	40.64
1080	147.36	46.27	93.57	119.78	119.78		72.18	35.55
1140	132.73	40.86	84.25	102.33	102.33		63.13	32.3

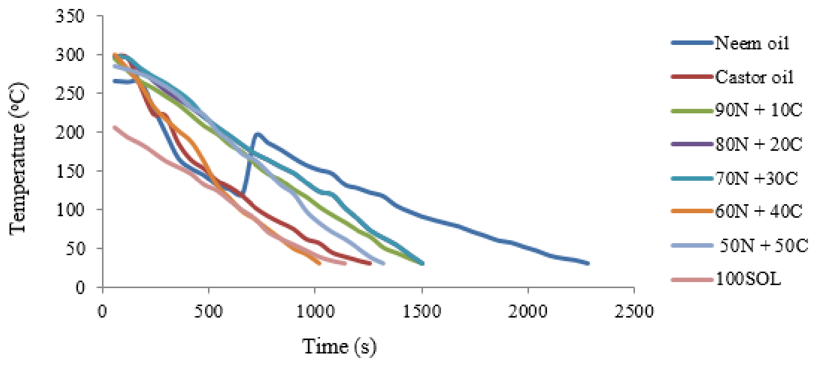

Fig. 1: Cooling curve for various blending ratio.

Table 3: Lubricity test.

Oil sample	Co-efficient of friction	Wear Scar dia. (mm)
100neem	0.25	0.29
100castor	0.20	0.16
90:10	0.21	0.17
80: 20	0.26	0.23
70:30	0.19	0.18
60 : 40	0.13	0.13
50: 50	0.17	0.15
Engine oils	0.32	0.38

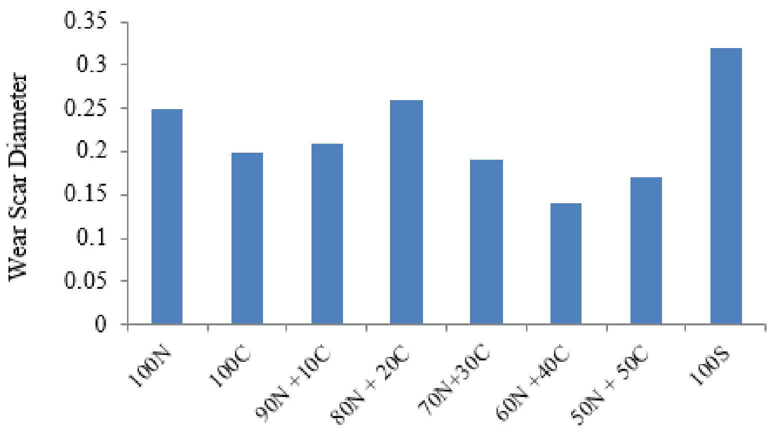

Fig. 2: WSD VS formulated lubricants.

6.0 DISCUSSION OF RESULTS

Table 1 presents the result of the physicochemical analysis of the individual oil and the blends ratio. It was observed that 100% neem oil exhibited high saponification value of (194.69MgKOH/g) which confirms its good quality for soap production, compared to 100% castor oil of 179.23MgKOH/g. Detergency means the act of cleaning , Therefore, a lubricant which has property of detergency act to clean the engine deposits free from sludge and other deposits. The viscosity of 100% neem oil at 23.6^{0}C was 12.00 cps as compared to

100%castor oil with viscosity of 65.0 cps, this shows that blending the two oils together will take care of this deficiency in 100%neem oil. The flash point temperature for 100%neem and 100%castor oil were 329^{o}C and 368^{o}C respectively, the high flash point confirms the absence of risk of fire at the boundary lubrication. The physicochemical results showed the emulsion stability of the two oils is good. Lubricants with poor stability tend to break down at high temperatures and form gummy deposits which stick on piston rings and bearings. It may also lead to formation of sludge in the presence of water. Sludge changes the viscosity of the lubricant and tends to clog the oil passage.

For 90% neem and 10% castor oil, the result obtained showed an improvement in the viscosity value of the blend from 12.0 cps for 100%neem oil to 21.33cps.This blend ratio is also characterized with high acid value (15.708MgKOH/g) and high viscosity index value of 56.The emulsion stability for this blend was excellent, when compared with 100% neem oil which showed acid value of 8.415MgKOH/g and viscosity index of 50.The emulsion stability obtained for 100%neem oil was good. For 80%neem + 20%castor oil, the physicochemical analysis showed decrease in viscosity value to 10.0cps from 12.00cps obtained for 100%neem oil but an increase in viscosity index to 55 from 50 obtained for 100 %neem oil was recorded, this blend is also characterized with an increase in flash point temperature from 329^{0}C for 100%neem oil to 368^{0}C. A considerable decrease in saponification value number was recorded from 194.69MgKOH/g for 100%neem oil to 9.817MgKOH/g. For this blend the overall emulsion stability was excellent. For 70% neem + 30% castor oil, the result obtained indicates an increase in viscosity value to 20.67cps from 12.0cps for 100%neem oil which is showing a better lubricity property for the blends. This blend is also characterized with an increase in flash point temperature of 370^{o}C from 329^{o}C for 100 %neem oil, an increase in viscosity index from 50 for100% neem oil to 54 but a considerable decrease in saponification value to 5.049MgKOH/g from 194.69MgKOH/g for 100%neem oil was recorded. For 60%neem+40%castor oil showed an increase in viscosity value to 27.33cps from 12.00cps for 100%neem oil, this result shows that as the quantity of castor oil is increasing in the blend, the lubricity properties of the blend is improving. This blend shows the highest values in the critical properties needed for lubricant. As the quantity of castor oil is increasing in the blend, the blend is showing an improved properties in viscosity, flash point, pour point, saponification number and viscosity index .This trend is a confirmation of superior properties of castor oil over neem oil and so this formulation has found the uses for abundant neem oil in the northern part of Nigeria. For rating the viscosity of lubricants, SAE

(Society of Automotive Engineers) has adopted a process under the specified standard conditions and allotted SAE member. These SAE numbers are related to fluid friction; a lubricant of SAE 60 is more viscous and offers more resistance than SAE 30 oil. A highly viscous lubricant absorbs more energy to move the engine parts whereas the low viscous lubricant fails to maintain the film of the lubricant between the moving parts and the parts run dry.

For 50%neem +50%castor oil blend ratio, the above trends continue but an increase in iodine value to 116.75g12/100g was recorded which reflect high proportion of unsaturated fatty acids in the blend. From the results, it was observed that 50%neem+ 50%castor oil showed the least values of pour point ranging from -42^oC to -38^oC. The neem oil products blend with castor oil has pour points ranging from -38^oC to -42^oC, while 100%neem and 100% castor oils have -38^oC and -39^oC respectively. Generally, it was observed that all the blend oil products have the pour points below 0^oC which is a desirable property for lubricating oil. Viscosity is a measure of an oil thickness and ability to flow at certain temperatures. Generally vegetable oils have the property of very high viscosity index. The lubricity of the various lubricants was further ascertained by evaluate the Wear Scar Diameter(WSD) of the rotating ball using tribometer tester, the minimum wear scar diameter of (0.13mm) occurred when the lubricant sample 60% neem oil and 40% castor oil blend was tested which is the optimum blend ratio in the experiment.

CONCLUSION

From the findings, it has been established that environmentally-friendly vegetable-based oil could successfully replace petroleum-based mineral oils in automobile engines with little or no modifications in the lubricant formulations, even better performing engine oil could be obtained. The following conclusion could be drawn from this work:

The optimum sample of oil blends falls within the range of 60%ceem and 40% castor oil, the blend possess the minimum requirements of a standard lubricant. This is because the sample possessed higher lubricity properties such as saponification value (39.83), iodine value of (81.23) and viscosity at 23.6^0C was (27.33).

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