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DETERMINATION OF SUITABILITY OF GROUNDNUT OIL AS A HYDRAULIC FLUID

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ABSTRACT: *This study is set out to ascertain the suitability of groundnut oil as a hydraulic fluid. Benchmark tests and experiment were carried out to ascertain the physio-chemical property of groundnut oil. The key steps will be to experiment the viscosity of groundnut oil at 40^{o}C and 100^{o}C respectively, specific gravity, viscosity index, acid value, Pour point, flash point, fire point, peroxide and iodine value using refined groundnut oil as sample. The result showed that the viscosity at 40^{o}C and 100^{o}C are 34.1mm^2/s and 7.08mm^2/s which exceeded the international standard organization (ISO) specification of (12-100) mm^2/s and 5mm^2/s for 40^{o}C and 100^{o}C respectively. The flash point (249.1^{o}C), the fire point (255.2^{o}C), acid value (0.3942mg (KOH)/g) all exceed the ISO specification. The result showed a good peroxide value and iodine value from oil sample. The low temperature flow property (pour point) is the only result that does not meet ISO specification with -3^{o}C but can be handled by addition of cold flow property depressant (additive). However this work has demonstrated the feasibility of using groundnut oil as a hydraulic fluid*.

KEYWORDS: Hydraulic-Fluid, Fluid-Properties, Groundnut-Oil, Pour-Point, Peroxide Value

INTRODUCTION

The present emphasis on conservation and environmental friendliness has brought about keen interest in the use of natural oil for industrial fluid. Their chemical composition and specific properties have allowed them to find use as foods, fuel and lubricants. Their sources are numerous, encompassing vegetable, animal, and marine sources. As it is with all matters their usefulness to man is determined by their chemical and physical properties and all fats and oils have certain characteristics in common. Hydraulic fluid can contain a wide range of chemical compounds, including oils, butanols, esters (e.g phthalates; like DEHP, and adipates, bis (2 – elhyexyl) adiptate), polyalkylene glycols (PAG), phosphate esters (eg. Tributylphosphate), silicons (PAO) (e.g. polyisobicteries), corrosion inhibitors. Hydraulic fluids are essential in driving circuit, cylinder, drive systems, manifold. Since, hydraulic fluids serve as the power transmission medium in a hydraulic system. However there are other important functions of hydraulic fluids. The demand place on systems constantly varies. Industries require greater efficiency and speed at higher operating require a basic understanding a particular fluids characteristics in comparison, with an ideal fluid. Although no single fluids have all of the said properties and functions. It is possible to select one that is the best compromise for a particular hydraulic system which requires knowledge of the system in which a hydraulic will

be used. The study is basically descriptive as it will served to investigate empirically, the degree physically and chemical properties of groundnut oil. Refined Groundnut Oil from Rivers State Vegetable Oil Company (RIVOC) will be used as oil sample. The physio-chemical properties of groundnut oil sample will be determined by experimenting and testing the oil sample. The experimenting will be done induplicate with the mean value calculated and used.

METHODOLOGY

The refined groundnut oil sample was tested using standard methods like American society for testing and material (ASTM) and the American Oil Chemistry Society (AOCS) and the Specification of hydraulic fluid oil from Automobile Engineering (SAE). The experimental analysis are designed to measure the physiochemical properties of the groundnut oil samples like: specific gravity, pour point, acid number, and iodine value, viscosity at 40^0C and 100^0C, peroxide value, flash point, fire point. Some of this experiment was conducted in RIVOC laboratory. The experimental analyses are also carried out to obtain the properties of groundnut oil and check if groundnut oil meets the specifications of the International Standard Organization (ISO).

EXPERIMENTAL DETERMINATION OF GROUNDNUT OIL HYDRAULIC FLUID PROPERTIES

The apparatus used theoretical formulas and methods observations and the results of the earlier mentioned hydraulic fluid properties of groundnut oil are analyzed below:

i) Acid Value: This is to determine the hydrolytic activates of the oil.
ii) Material and Apparatus: Weighing bottle, measuring cylinder, conical flask, burette and pipette. Refined groundnut oil, ethanol, phenolphthalein sodium hydroxide, distilled water.

The acid number is the amount of sodium hydroxide (mg) necessary to neutralize the free fatty acids 0.1g of oil sample. It can also be measured of partial hydrolysis by moist air. Oxidation products are formed by thermo-oxidative degradation of the oil, and oxidation occurred due to the inherent unsaturated nature of oil. Thermo oxidative degradation of the oil, forms peroxides and then undergoes further reaction to form alcohols, kefones, and carboxylic acid. The oxidation is indicated by acidic content of oil sample. 0.1g of groundnut oil sample was dissolved in a mixture of $25m^3$ distilled waters inside $250cm^3$ beaker. The $25cm^2$ mixtures was poured unto a $250cm^3$ conical flask. A few drop of phenolphthalein was added as indicator. The mixture titrated with 0.1N of sodium hydroxide to the end point with constant shaking for which a dark pink colour was observed and the volume of 0.1N (KOH) used. The equations below will be used to calculate the acid value

$$AV = \frac{M_{KOH}}{M_{OIL}} \quad (1)$$

$$M_{KOH} = V_{KOH} \times M_m \times M_c \times 10^{-3} \quad (2)$$

Where

AV = acid value in mg(KOH)/g, M_{oil} = mass of oil sample used in grams M_m , M_c , M_{KOH}, V_{KOH} = molar mass ,concentration, mass and volume of KOH in g/mol, mol/dm^3, mg and cm^3 respectively.

Observations

The reading from acid value experiment is tabulated in table1 below.

Table1:Readings from Acid Value experiment

Description	Symbol	Unit	Value
Volume of KOH used	V_{KOH}	Cm^3	7.04
Molar mass of KOH	M_m	g/mol	56

Determination of Specific Gravity

Determine the compatibility of the groundnut oil sample in water with Apparatus (Specific gravity bottle and weighing scale). Density is the mass per unit volume of a substance. The measurement of density can be achieved by the idea of relative density. The specific gravity (SG) of a substance is the ratio of ass of substance and equal mass of water. Weighed specific gravity bottle of $50cm^2$ capacity was filled with distilled water of 35^0C to overflow and inserted the stopper. After 30 minutes the bottle was removed from the water bath and wiped dry. The weight of the bottle and the content was taken and cooled to 35^0C and filled to dried specific gravity bottle. The weight of the bottle and groundnut oil sample was taken then for. The equation below will be used to calculate the acid value

$$SG = \frac{m3 - m1}{m2 - m1} \quad (3)$$

Where

M_1 = Weight for SG bottle in grams, M_2 = Weight of SG bottle + water in grams

M_3 = Weight of SG bottle + groundnut oil sample in grams

3.3.2.1 Observations

The reading from specific gravity experiment is tabulated in table 2 below.

Table 2:Reading from acid value experiment

Description	symbol	unit	Value
Weight of specific gravity bottle when empty	M_1	g	29.29
Weight of specific gravity bottle when filled with water	M_2	g	79.46
Weight of specific gravity bottle when filled with groundnut oil	M_3	g	75.46

Determination of Pour Point

The pour point of the substance is that temperature of which there is no movement of the oil when the test jar is held in horizontal position for five seconds with an apparatus (Holding

cylinder, boiler and cooling bath). ASTM method was will be used as $50cm^3$ of refined groundnut oil sample will be poured into a holding cylinder. The sample will be heated to 45^0C and then cooled with ice blocks. A temperature will reached were the sample oil will no longer move after 5 seconds of observing the holding cylinder. This temperature corresponds to the pour point temperature, T_1.

Observation

The reading from peroxide value experiment is tabulated in table 3 below.

Table 3:Readings from peroxide value experiment

Description	Symbol	Unit	Value
Temperature in which sample refuse to move after 5 seconds	T_1	^oC	-3

Determination of Flash and Fire Point

Flash point is the temperature at which we saturated vapour of groundnut oil sample will ignite. The materials used are infrary gun thermometer, open cup, torch nozzle and heater. ASTM method was also used when $50cm^3$ of groundnut oil sample was poured in an opening the cup was placed on the heater. Heat was applied at constant rate, flames from the torch nozzle was directed over the heated groundnut oil sample at different intervals. The first spark was reached when the torch flame ignited the saturated vapour of the oil sample; the thermometer reading at this point gives the flash point temperature. As heat was continuously applied to the samples a second spark was observed which lasted for just 5 seconds which gives the fire point.

Observations

The reading from flash and fire point experiment is tabulated in table 4 below.

Table 4: Reading from Flash and Fire point experiment

Description	Symbol	Unit	Value
Thermometer reading at point of first spark	P_{flash}	^oC	249.1
Thermometer reading at point of flame	P_{fire}	^oC	255.2

Determination of Viscosity at 40^0c and 100^0c

This is aimed to achieve the thickness of groundnut oil sample to operate at varying temperature and it compatibility. The following materials were used Canon fenkse (viscometer), viscometer bath, distilled water, and refined groundnut oil sample. The viscosity of groundnut oil determined the flow of the oil. These properties are determined by measuring the kinetic viscosity using canon fenke viscometers and which they are assigned to their viscosity grade of ISO VG 32 and ISO VG 46 grades are most popular. $100cm^3$ of refined groundnut oil sample was poured into the viscometer cup. The cup was placed in a viscometer bath containing water, which was switched to get temperature which is to be experimented at 40^0C and 100^0C respectively. The sample was slowly run into the viscometer and allowed for 15 minutes, the sample was sucked up the capillary tube, above the upper

mark when the sample dropped to the stop watch was started and it was stopped when he sample reached the lower mark. The product of the time and viscometric constant is the viscosity. This was achieved in triplicate in which the mean result was attained.

Observations

The reading from viscosity experiment is tabulated in table 5 below.

Table 5: The reading from viscosity experiment

Description	Symbol	Unit	Value
Time taken for groundnut oil at 40^{o}C to reach lower mark on viscometer.	T_{40}	sec	34.10
Time taken for groundnut oil at 100^{o}C to reach lower mark on viscometer.	T_{100}	sec	7.08
Viscometric constant of viscometer.	V_c	mm^2/s^2	1.0

Examination of Peroxide Value

Peroxide value indicates if the sample oil can resist lipolytic and oxidation deterioration when stored. The apparatus used are Boiling tube, conical flask, pipettes, and burettes and weighing scale. The material used are Powered potassium iodine, chloroform, glacial acetic acid, distilled water, 0.025N disodium trioxosulphate (IV) solution and refined groundnut oil sample. When oxygen content in a sample reacts, it is known as peroxide value which is given in terms of mili-equivalent per kilogram. Oxidation stability is caused by the high content of unsaturated acid which helps in developing peroxide under poor storage condition. They indicate oxidation in the early stage of oil deterioration in which the rate became reliable during the later stage of deterioration. The peroxide value is achieved by titrating iodine liberated with disodium trioxosulphate II solution. The amount of iodine which is formed by the reaction of peroxide contents in sample with iodine ion.

$$2I + H_2O + ROOH \longrightarrow ROH + 20H + I_2 \quad (4)$$

Ig of the refined groundnut oil sample was weighted in a clean dry boiling tube. 10g of powered potassium iodide and 10cm^3 of solvent mixture, 2 volume of glacial acetic acid and 1 vol. of chloroform were added to the sample and the mixture was poured into a flask containing 10cm^3 of 5^{0}C potassium Iodide, few drops of starch solution were add to the mixture and was titrated with 0.01N disodium trioxosuphate (IV).

$$I_2 + 2Ha_1\ S_2\ O_3 \longrightarrow Na_2\ S_4\ O_6 + 2NaI \quad (5)$$

$$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I \quad (6)$$

$$\text{Peroxide value} = \frac{V \times N \times 10^3}{W} \quad (7)$$

Where

N = Normality of $Na_2S_2O_3$ in mol/dm^3, W =Weight of oil in grams

V = Volume of $Na_2S_2O_3$ used in cm^3

Observation

The readings from the experiment are shown in table 6 below

Table 6: Readings from peroxide value experiment

Description	Symbol	Unit	Value
Volume of $Na_2S_2O_3$ used	V	Cm^3	2.31

Determination of Iodine Value

The iodine value indicates low degree of unsaturated acid and classifies them as non-drying oil with apparatus (The Beakers, flask, iodine filtration flask, burettes and weighing scale). The materials used are Starch solution, distilled water, iodine monochloride carbon tetrachloride solution, potassium iodine (KI) $100g/dm^3$ solution, and 0.1 disodium trioxosulphate (IV) $Na_2S_2O_3$ (500g). The iodine value indicates the degree of unsaturated acid linage in the oil sample. Using the method specified by ISO 3961 (1989) for obtaining iodine value, 0.1g of the refined groundnut oil sample was weighted into a conical flask and $20cm^3$ of Dam reagent was added and the flask was paled in the dark for 2 hours 30 minutes at end of this period, $20cm^3$ of 10% aqueous potassium iodine and $125cm^3$ of distilled water was added using a measurable cylinder. It was titrated with 0.1N of di sodium trioxouplhate (II) solution until colour charge to permanent pale yellow.

$$\text{Iodine value} = \frac{12.62 \times c \times (v_2 - v_1)}{M} \quad (8)$$

Where:

C = Concentration of disodium trioxosulphate (IV)

V_1= Volune of disodium-trioxosulphate (IV) (NA_2SO_3) used for blank

V_2= Volume of disodoum-trioxosulphate (IV) (NA_2SO3) used for end point

M= Mass of refined groundnut oil sample used

Observation

The readings from the experiment are shown in table 7 below

Table 7: Readings from iodine value experiment

DESCRIPTION	SYMBOL	UNIT	VALUE
Volume of NA_2S_2O3 used for blank titre	V_1	Cm^3	38.95
Volume of NA_2S_2O3 used for end point	V_2	Cm^3	31.96

ANALYSIS AND DISCUSSION OF RESULT

The results obtained from the test and experiment in the previous sections. The computations are done using matlab. The results are compared with other biodegradable hydraulic fluid and with the specifications of the society of automotive engineering (SAE) and the international standard organization (ISO).

Table 8: Pysio-chemical properties of groundnut oil experimental result performed.

Properties	**Testing method**	**Unit**	**Result**
Density at 15^0C	ASTMD 1298-85	kg/m^3	920.0
Specific gravity at 35^0C	ASTMD 287	-	0.914
Pour point	ASTMD 92-90	^{0}C	-3.0
Flash point	ASTMD 92-90	^{0}C	249.1
Fire point	ASTMD 445	^{0}C	255.2
Viscosity AT 40^0C	ASTMD 445	mm^2/s	34.10
Viscosity at 100^0C	ASTMD 445	mm^2/s	7.08
Viscosity Index	ASTMD 2270	-	214.0
Acid Value	ASTM 664-89	mg(KOH)/g	0.394
Iodine Value	ISO 396	mg/g	88.214
Peroxide Value	WIJ	meq/g	2.310
Saturated Fatty Acid	AOCS –CE 266	%	17.26
Unsaturated Acid	AOCS – CE 266	%	80.74

Table 9: Physio chemical properties of groundnut oil by previous researchers in the United States of America (Aluyor and others ,2009)

Properties	**Testing method**	**Result**
Density at 15^0C kg/m^3	ASTMD 1298-85	921.4
Specific gravity at 35^0VCg	ASTMD 287	0.918
Heating Value ^{0}C	ASTMD 240-92	39.5
Flash point ^{0}C	ASTMD 92-90	271
Pour point ^{0}C	ASTMD 97-93	-13
Viscosity AT 40^0C Cst (mm^2/s)	ASTMD 445	36.9
Viscosity at 100^0C cst (mm^2/s)	ASTMD 445	6.9
Viscosity index	ASTMD 2270	238
Acid number mg/KOH/g	ASTMD 664-89	0.159
Iodine value cy/g	AOC-CD- 16-87	96
Sponification value mg KOH/g	AOCS-CE 39-94	196
Saturated fatty acid %	AOCS-CE 2-6.6A	25

Table10: Commercial vegetable oil (rape seed) hydraulic fluid (www.wiserenewable.com, 2008).

Properties	**Testing method**	**Result**
Density at 15^0C kg/m^3	ASTMD 1298-85	921.4
Specific gravity at 35^0VCg	ASTMD 287	0.874
API gravity at 15.6 ^{0}C	ASTMD 287	30.4
Viscosity AT 40^0C Cst (mm^2/s)	ASTMD 445	30.87
Viscosity at 100^0C cst (mm^2/s)	ASTMD 445	6.9
Viscosity at -15^0C Brook field) Cst (mm^2/s)	ASTMD 2983	550
Viscosity at -35^0C (MRVTP)	ASTMD 4684	2679
Viscosity index	ASTMD 2270	184
Pour point ^{0}C	ASTMD 97	42
Flash point ^{0}C	ASTMD 92	236
Fire Point ^{0}C	ASTMD 92	260
Foam sequence	ASTMD 92	Zero foam
Acid Value mg/KOH/g	ASTMD 974	0.37

Table 11: International standard organization (ISO) specification for maximum efficiency hydraulic fluid (MEHF) (Kesly, 2008)

Characteristic	**Limit**
Viscosity grade ISO VG	32
Viscosity at 40^0C Cst (mm^2/s)	12-100
Viscosity at 100^0C cst (mm^2/s)	> 5.0
Viscosity index	>150
Flash point ^{0}C	198
Pour point ^{0}C	- 12 maximum
Fire Point ^{0}C	>218
Acid value mg KOH/g	1.5<
Foam sequence 10 minutes	Zero foam
Water	Pass
Preferred viscosity range	Less than 10%
Viscosity index	Typical 95-110 for ordinary hydraulic fluid 140-149 for premium hydraulic fluid >150 for MEHF
Copper corrosion	Pass
Rust test	Pass

DATA ANALYSIS

The experimental data from table.9 above shows the physiochemical properties of refined groundnut oil which was conducted in Rivers State Oil Cooperation (RIVOC) in Port Harcourt, Nigeria. The results are presented in table 9.

Specific Gravity

The density of the refined groundnut oil sample was obtained to check the level of groundnut oil compatibility with water which means the ability of the oil to separate from water. The result showed groundnut oil with density at 15^0C to be 920 kg/m^3 which will help in the case of contamination caused by bacterial due to its mixture with water. Thus for maximum efficiency hydraulics fluid (MEHF) is 0.87 to 0.874 in ISOVG 32, 46 and 68 hydraulics fluid.

Acid Value

The experimental result shows an acid value of 0.3944 mgKOH/g in the groundnut oil sample which means that there will be very low level of hydrolytic activity in the oil, and will be corrosive to soft metal parts of hydraulic system. The ISO specification for hydraulic fluid acid is 1.5 mgKOH/g (max) of which groundnut oil is below the specified value.

Pour Point

Observation when pour point experiment showed that the refined groundnut oil have a pour point of 3^0C. Thus, this study has shown that groundnut oil pour point ranges from – 12 to 4^0C. Thus the International Standard Organization (ISO) specified- 12^0C (max), since the unsaturated acid leads to the rapid oxidation stability at elevated temperature and poor low temperature flow properties. The low temperature fluidity can be improved by additives.

Flash and Fire Point

The flash point in the experiment conducted was observed to be 249.1^0C and the fire point of the refined groundnut oil sample was observed to be 255.2^0C. The sample oil show great response to the heart and flame at elevating temperature. The flash point meets the (ISO) specification for biodegradable hydraulic fluid which is 198^0 for flash point and 218^0C for fire point.

Viscosity and Viscosity Index

The viscosity of a groundnut oil sample was operated at 40^0C and 100^0C respectively. The result experimentally showed that at 40^0C respectively. The result experimentally showed that at 40^0C and 100^0C respectively, the viscosities were 34.10 (mm^2/s) and 7.06 (mm^2/s) respectively. Form the maximum efficiency hydraulic fluid (MEHF) specification in table.11 the specified limit is *(12-100) mm^2/s for 40^0 C, and above 5.0 mm^2/s for 100^0C from the result above the oil will be grade in ISO VG 32 for (MEHF). The (MEHF) specification for a viscosity index of groundnut oil is 150 minimum. The determined viscosity index of groundnut oil is 214, which have exceeded the minimum limits for requirements of hydraulic fluid. Hydraulic fluid viscosity lessens with change in temperature. The higher the number

the lesser the viscosity change in temperature, a higher groundnut oil viscosity index can allow a fluid to be used year round, eliminating seasonal change, out between summer and winter fluid. It leads to cooler operating temperature avoiding unscheduled shunt down due to overheating. Therefore it can be said thaw groundout oil has good thermal stability compared to some mineral oil hydraulic fluid.

Peroxide Value

This result shows that the peroxide value of the experiment of refined sample is 2.31meq/g low content of peroxide value indicates that refined groundnut oil sample and resist lipolytic hydrolysis and deterioration.

Iodine Value

This was observed to be 88.70cg/I_2/g. The result shows that groundnut oil shaves highest value of unsaturated fatty acid which causes oxidation stability. According to Jacqualin (1986) iodine number from 60 to 128 is suitable or the purpose of hydraulic fluid.

Biodegradability

The biodegradability of groundnut oil undergoes about 70 -100% biodegradation. The groundnut is not toxic to plant and animal, micro and macro organism in the ground.

Additives Used In Vegetable Based Hydraulic Fluid

Shortcomings of vegetable oils, such as low thermo-oxidative stability and poor cold flow behavior may be improved through the use of additives that enhance oxidative stability, improve low temperature property (pour point) and confer better wear properties.

Cold Flow Improvers or Depressant

Functional **PD-551, PD-555** and **PD-557** modify the wax crystal performance of lubricants. These products are called either pour point depressants or Cold Flow Improvers. Their primary use is to improve the cold flow properties of vegetable oil based lubricants at temperatures below their cloud points. These products are effective under both rapid-cooling and extended cold storage conditions. Our Cold Flow Improvers are effective in hydraulic fluids, chain saw oils, pneumatic tool lubricants and other lubricants made from canola oil, sunflower oil or other triglycerides. The low viscosity of **PD-555** makes it very easy to handle.

Oxidative Stability Improvers

Because of their triglyceride structure, vegetable oils generally have poor oxidative stability that may contribute to oil failure. Rapid increase in viscosity, sludge and deposit compromises the performance of the lubricant and contaminates filters. For an economic anti-oxidant for vegetable oils, **FUNCTIONAL** recommends **AO-510** which, at treat rates as low as 0.15% by weight, greatly enhances oxidative stability. For premium performance, **AO-520** may be used.

Anti-Wear Improvers

i) FUNCTIONAL HF-500 is an additive package for making hydraulic fluids based on vegetable oils for situations where the lower environmental impact is important. **FUNCTIONAL HF-500** provides oxidation and corrosion protection, extreme pressure / anti-wear activity and resistance to water. It contains neither phenols nor substances that give a positive EPA phenol test.

ii) FUNCTIONAL HF-546 is an additized package for making ISO 46 hydraulic fluids. It is formulated to provide excellent anti-wear and corrosion resistance, oxidative stability, foam resistance, cold flow properties and resistance to water. **HF-546** and **HF-560** are compatible with TMP trioleate diluents for increased thermal and oxidative stability.

iii) FUNCTIONAL HF-560 is an additive package for making Military Specification MIL-PRF-32073 type hydraulic fluids based on biodegradable esters or vegetable oils. **FUNCTIONAL HF-560** provides oxidation and corrosion protection, extreme pressure / anti-wear activity, foam resistance and resistance to water. We recommend using refined vegetable oils to pass the Military oxidation requirement. To improve the oxidative stability of the vegetable oil, **FUNCTIONAL AO-510** or **AO-520** may be used at a 0.15-0.25%**.** One important consideration in choosing these additives is that they are ash less so not to introduce large amount of metal in case of spills.

CONCLUSION AND RECOMMENDATION

Conclusion

From the analysis made from the previous chapter groundnut oil have many properties which are of advantages especially in hydraulic fluid. The viscosity stability of groundnut oil at elevating temperature is stable. It was concluded that viscosity index of groundnut oil (214) are clearly higher than that of hydrocarbon (120) with no additives. This is of consideration importance, under conditions in which the operating temperature may vary within rather limit. The specific gravity exceeded the international standard organization (ISO) specification of 0.879 to 0.874 whereas result was 0.914. The acid value form the result show that groundnut oil will have low level of hydrolytic activity in hydraulic systems. The flash, fire, and pour point all passed the ISO specifications. Also peroxide value determined shows that the oil sample (groundnut oil) can resist lypolitic hydrolysis and deterioration during storage. While iodine number was 88.70cgI_2/g which shows that groundnut oil has high value of unsaturated fatty acid which causes oxidation. Nevertheless, it has been shown that groundnut oil (Arachis hypogaea) is suitable for hydraulic fluid. That the only two properties of the said trighlycerides which would impede their intended use for hydraulic purpose is their low temperature flow properties and oxidation stability. Thus the use of additives can be used to improve the pour point and oxidation stability. Therefore the research work has shown that "groundnut oil" is suitable for hydraulic fluid.

Recommendation

From the conclusion, the following recommendations are made to convenience the hydraulic industries to change the trends of hydrocarbon hydraulic fluid to vegetable oil hydraulic fluid for the use of hydraulic equipment. The future research that will embark on this research work should look at the minimum and maximum pressure to exact on groundnut oil to be certain if there is cavitations in the fluid. Determine the physio-chemical properties of roasted groundnut and compare the oils with refined groundnut oil to see if there is improvement.

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