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Extraction and Analysis of Chemo-physical Properties of Yellow Oleander Oil as Lubricant

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Authors' contributions

Author MIO identified the problem, set the objectives, designed the methodology and supervised the entire project work. Authors MIO, BEA and IOO reviewed the relevant literature. Authors BEA and IOO collected materials for the analysis while the analysis was done by authors MIO, BEA and IOO. The draft manuscript was produced by authors BEA and IOO while Author MIO did the final review as was agreed by the three Authors.

Original Research Article

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ABSTRACT

Yellow Oleander (*Thevetia Peruviana*) oil has been extracted and analyzed relevant to lubrication. Oil was extracted from yellow oleander seeds using mechanical expression and solvent extraction methods. Samples generated from these oils were subjected to chemo-physical analysis. Analysis of chemo-physical properties (such as viscosity, specific gravity, viscosity-temperature coefficient and fire point among others) was carried out using simple laboratory equipment. Results obtained showed that yellow oleander oil have properties that fall within the range of standard oil lubricants. High flash and fire points of 350°C and 375°C respectively were obtained. Free fatty acids content of 5.61% against a standard range of 35%-50% for natural oils. Specific gravity of 0.89-0.92 was obtained against a standard range of 0.76-0.92 for oil lubricants. The oil can be used as lubricant in environmentally sensitive areas such as total loss lubrication and marine ecosystems with associated positive environmental and economic impact.

Keywords: Analysis; chemo-physical; extraction; lubricant; oleander oil; properties.

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1. INTRODUCTION

Growing environmental awareness, concerns of economic security and more stringent regulations regarding petroleum products have spurred renewed interest in natural oils as alternative lubricants. Three main types of oil lubricants are currently in use viz; mineral oil-based lubricants (also called mineral oils) – derived from petroleum crude oil, synthetic lubricants and plant-based lubricants (or biodegradable natural oils). Mineral oils are predominantly in use. Synthetic lubricants are formulated to possess specific high performance properties. Plant-based lubricants are derived from naturally occurring oil seed. This work seeks to analyze the chemo-physical properties of Yellow Oleander (*Thevetia Peruviana*) oil as alternative lubricant. The choice of Yellow Oleander oil was motivated by its abundance and ease of cultivation of the oil crop in short rotation plantations.

The yellow oleander plant belongs to the family of plants called *Apocynaceae.* It is a small tree or shrub with yellow, bell-shaped flowers native to the Mediterranean regions of Southern Europe and South West Asia [1]. In Nigeria, it thrives in almost every part and it is grown in most parts of the country for horticultural purposes due to its beautiful flowering habit. Flowering occurs all year round with most profuse flowering occurring at warmer months. It is a fast growing crop and takes between one and three years to fruit. Transplants of oleander are easy from woody stem cutting. The fruit of the yellow oleander plant is trapezoidal in shape with fleshy green epicarp that turns black before dropping. It has a hard brown nut which is also trapezoidal in shape, having two to four seeds in it. The seeds have high oil content. It is a tropical/tender perennial plant that grows up to a height of between 3-3.6m and blooms all year. The soil pH requirement for the plant is between the ranges 6.6-7.5 or 7.6-7.8 [2].

Yellow oleander oil can be extracted from the seeds by mechanical pressing and solvent extraction methods. Solvent extraction is employed in large scale operations for a more complete extraction than is possible with mechanical pressing using N-heptane, N-hexane, ethanol, etc.

Oils are evaluated for lubrication performance by determining their chemo-physical, thermal, frictional and rheological properties and characteristics. The chemo-physical properties include viscosity, viscosity Index, density, specific gravity, bulk modulus or compressibility, flash point, surface tension, oiliness, freezing point, fire point, cloud point, appearance/color, odor and water content. Recognition of these properties is useful for designing lubrication systems, choosing lubricating oils, diagnosing lubrication, friction and wear problems and also for selecting appropriate testing methods [3].

Sheanut, groundnut and palm kernel oils were worked on as alternative lubricants in upset forging. The extraction and saponification of rubber oil as well as the effect of processing conditions on the rheology of palm oil carried out [4,5]. The rheology of canarium oil and the rheology of palm, soy, rubber and gmelina oils as alternative lubricants were investigated [6,7]. The yellow oleander oil crop is not well established as a source of raw material for oil lubricant production. The basic quality parameters of palm oil (i.e. saponification values, iodine value, acid value, refractive index) varies with processing methods [8]. Soy bean has high oil content fatty acids such as oleic acid, stearic acid, palmitic acid, linoleic acid among others [9]. Rubber seed oil contains fatty acids which endears it to the cosmetic and paint industries [4]. Although rubber seed oil viscosity is high, its odour is objectionable due to degradation and oxidation reactions of fatty acids, glycerides and other proteins in the raw oil.

Large quantities of Yellow Oleander (*Thevetia peruviana*) seeds are wasted annually on the ground in various parts of Nigeria. This work seeks to determine the suitability of yellow oleander oil as alternative machine lubricant by evaluating its chemo-physical properties, and establish the need for the cultivation of yellow oleander in commercial quantities.

2. METHODOLOGY

Yellow oleander fruits were picked from ornamental gardens around Makurdi town while laboratory equipment were obtained in the Food Chemistry and Mechanical Engineering laboratories of the University of Agriculture, Makurdi. Gravimetric analysis was carried out to generate baseline data for the selected oil seeds to indicate future investment potential of the seeds while different extraction methods were used to establish comparative advantage of the methods.

2.1 Gravimetric Analysis of Oil Seeds

Fresh yellow oleander fruits were weighed using weighing scale (Denver instrument model XR1500) and the average weight was recorded. The fruits were left to undergo biodegradation for two weeks, after which the nuts were removed. The nuts were manually cracked to remove the oils seeds. The weights of the nuts and oil seeds were noted and their respective average weights were recorded.

The moisture content of the oil seeds was determined by drying a measured quantity of the seeds in electric oven (Genelab model B65) to constant weight at 105°C.

$$\text{Moisture content} = \frac{\text{Initial weight of oil seed}}{\text{Final weight of oil seed}} --------- (1)$$

The following ratios were determined using equations (2) to (4).

$$\text{Fruit/Oil seed ratio} = \frac{\text{Weight of fruit}}{\text{Weight of oil seed}} ------------- (2)$$

$$\text{Nut/Fruit ratio} = \frac{\text{Weight of nut}}{\text{Weight of fruit}} ----------- (3)$$

$$\text{Fruit/Nut ratio} = \frac{\text{Weight of fruit}}{\text{Weight of nut}} ----------- (4)$$

In order to determine the oil / oil seed ratio, the measured portion of the oil seed was pulverized using grinding machine and oil was extracted using the solvent extraction method with ethanol as solvent . The oil / oil seed ratio was determined using equation (5).

$$\text{Oil / Oil seed ratio} = \frac{\text{Weight of oil from oil seeds}}{\text{Weight of oil seeds}} ---------- (5)$$

2.2 Oil Extraction by Solvent Method

Oil was extracted from the oil seeds of yellow oleander using the solvent method [4,10]. The mesocarp of yellow oleander nuts was manually cracked to remove the oil seeds. The oil seeds were dried to average constant weight of 0.40g in the oven and the seeds pulverized into paste using a laboratory grinder. The paste was mixed with ethanol at 45°C over a hot plate (Stuart model) for one hour in a mass ratio of 0.9/0.1 (liquid/solid). The mixture was filtered with a sieve of 0.1μm mesh size to obtain a full miscella. The miscella was placed in a distillation column and then distilled at 110°C to obtain yellow oleander oil. The oil was dried in electric oven at 105°C for two hours to reduce the moisture content in the oil. The ethanol used was recovered up to 98% recovery.

2.3 Oil Extraction by Mechanical Expression Method

Mechanical expression method was also used to extract yellow oleander oil [10]. Yellow oleander oil seeds dried to constant weight in the oven were ground into fine paste using a laboratory grinder. 50mg of boiling water (100°C) was added to a portion of the paste and thoroughly mixed. This mixture was poured into the remaining portion of the paste and thoroughly mixed at 60°C over a hot plate for an hour. The addition of boiled water was to agitate the oil in the oil matrix to ensure a high percentage of removal oil from the oil seeds. The paste was poured into a filter material with a mesh size of 0.1μm and squeezed in a laboratory hydraulic press gradually until the oil was drained from the oil seeds. The oil obtained was dried at 105°C for one and half hours in the electric oven to reduce moisture content of the oil. The oil was packaged into containers.

The samples were generated from one litre of the reference oil (Regal 32) and half a litre each of yellow oleander oil obtained from the two extraction methods as shown in Table 1.

Table 1. Straight and blended oils for chemo-physical analysis

Sample	Regal 32	:	Yellow Oleander Oil
A_1	1	:	0
A_2	0	:	1
A_3	1	:	10
A_4	1	:	20
A_5	1	:	30
B_1	1	:	0
B_2	0	:	1
B_3	1	:	10
B_4	1	:	20
B_5	1	:	30

2.4 Chemo-physical Analysis

The following analyses were conducted on the oil samples: specific heat capacity, free fatty acids content, specific gravity, oil retention test, flash point, fire point, cloud point, pour point, foamability, foam stability, viscosity and viscosity – temperature coefficient. Specific heat capacity was determined as described in ASTM D3947 using differential calorimeter, free fatty acids content was determined as described by [11]. Specific gravity (ASTM D-1298), flash and fire points (ASTM D-92), oil retention, pour point (ASTM D-97) and viscosity (IP71/ASTM D-445) were determined [12]. Foam ability and foam stability (ASTM D-892) and viscosity- temperature coefficient were determined [3,13].

3. RESULTS AND DISCUSSION

3.1 Gravimetric Performance

Table 2 shows the results of the gravimetric analysis of yellow oleander seeds. In the table, four basic ratios were established for the oil seeds. These ratios were oil / oil seed ratio (0.02), oil seed / nut ratio (0.10), nut / fruit ratio (0.22) and oil seed / fruit ratio (0.02). These ratios facilitate the determination of oil yield from a given quantity of fruits. It is therefore possible to determine the impact of oil produced on the upstream agricultural activities. In carrying out a feasibility study of production and materials requirement for lubricants production, these ratios play a predominant role. Thus, a knowledge of the quantity of fruit required for a given oil base stock, determined from these ratios would provide the upstream yellow oleander farmer with a knowledge of the farm size required. The oil / oil seed ratio obtained was lower than oil / oil seed ratio obtained for gmelina oil seed (0.16) and rubber oil seed (0.08) [14]. Therefore, for a given quantity of yellow oleander, gmelina and rubber oil seeds, oil yield are expected to be lowest in yellow oleander oilseeds. However, oilseed / nut ratio of 0.10 obtained in this work, gives a lower waste generation during the actual lubricant production.

Table 2. Gravimetric analysis of yellow oleander oil seeds

Items	Values
Average Weight of Fruit (Fresh), g	18.85
Average Weight of Nut, g	4.19
Average Weight of Oilseed, g	0.40
Moisture Content in Oilseed, %	2.73
Percentage of Oil in One Oilseed, %	21.3
Fruit to Oilseed ratio	0.02
Nut to Oilseed ratio	0.10
Fruit to Nut ratio	0.22
Oil to Oilseed ratio	0.02

3.2 Chemo-physical Analysis

In Tables 3 and 4, the chemo-physical properties of oil samples are shown. Table 3, shows the chemo-physical properties of oil samples obtained by mechanical expression. In the table, the odor of yellow oleander oil, the reference oil and the blends were mild. This was contrary to the findings of [4] for rubber seed oil, whose use was discontinued at Delta Steel Complex, Aladja, Nigeria due to offensive odor. Yellow oleander oil obtained by solvent extraction method was also found to have mild odor. The use of yellow oleander oil and its blends as lubricants will be conducive to workers on the basis of odor.

The specific gravity of yellow oleander oil and the blends in Table 3 fell within the range of 0.906 and 0.912, while in Table 4, the specific gravity fell between 0.84 and 0.89 for the oil extracted by solvent extraction. The specific gravity fell within the standard range of 0.76-0.92 for oil lubricants [3]. The disparity between the specific gravity of oil samples obtained was possibly due to loss of wax from the solvent extracted oil arising from heat input during extraction. The disparity in specific gravity between the reference oil and yellow oleander oil and the blends was possibly due to the processing undergone by the reference oil.

The cloud points of yellow oleander oil and its blends in Tables 3 and 4 fell within the range of 6°C and 9°C and the pour points for yellow oleander oil fall between the range of 4°C and 7°C respectively. However, it was observed by [3] that the lower the cloud and pour point of oils, the better the pumping property at start-up of engines at relatively low temperatures. The reference oil had relatively lower pour and cloud points than the yellow oleander oil and its blends possibly due to absence of wax and other contaminants. Compared to some natural oils such as gmelina, rubber, palm, soy, ground nut, shear butter and wild melon oils, the pour point of yellow oleander is very good and can easily be improved by treatment with pour point depressants such as ethylene-vinyl acetate and polyalkylmethacrylates [4,16,17].

Natural oils generally have high flash and fire points which make them very safe as lubricants in fire-prone operations. The flash and fire points obtained for yellow oleander and its blends as shown in Tables 3 and 4 were exceptionally higher than the reference oil. The flash point of yellow oleander oil was high when compared with rubber seed oil, wild melon oil, palm oil and gmelina oil [14]. Industrial fire is a serious hazard often encountered in lubrication where accidental increases in temperature are encountered due to acts of negligence. Under this condition, oils with high flash and fire points will prove invaluable. The high flash and fire points for yellow oleander oil would provide safe machine lubrication.

The ability of oil to remain in the bearing after application determines to a large extent the functional stability of that oil. Yellow oleander oils retention property was higher than that of the reference oil as shown in Tables 3 and 4. This was because yellow oleander contained more wax than the reference oil. In machine lubrication, the apparent good retention property of yellow oleander oil would be eroded when the machine attains its operating speed, as a result of melting of the wax material in the oil. However, in boundary lubrication this oil retention property enhances the adsorptive behavior of the oil. The percentage retention of yellow oleander oil (40.51%) was observed to be higher than that of rubber seed oil (7.69%), gmelina oil (9.42%), palm oil (33.19%) and soy oil (3.52%) [14]. The difference in oil retention can be attributed to differential molecular affinity between the various natural oils and solid boundaries.

The pH values of the yellow oleander oil and its blends in Tables 3 and 4 fall within the ranges of 4.15 - 5.83 and 4.10 – 5.90. It was observed that the pH values in Tables 3 and 4 are lower than that of the reference oil which was an indication that they are more acidic than the reference oil. The acidity of oil provides a reference point for monitoring oil condition during use. An increase in acidity of oil during use as a lubricant shows the accumulation of oxidation products in the oil. This is therefore a primary factor in condition-based maintenance of engineering mechanisms.

The specific heat capacity of the oil samples is as shown in Tables 3 and 4. The specific heat capacity of the reference oil (19500J/kgk^{-1}) was higher than that of yellow oleander oil and its blends. This was because the reference oil has undergone processing to enable it perform specific industrial lubrication functions. Addition of yellow oleander oil to the reference oil gave rise to a progressive decrease in the specific heat capacity of the blends which was lowest at A_5 (4410.02J/kgk^{-1}) and B_5 (4437.70J/kgk^{-1}). The specific heat capacity of oil determines the amount of heat the oil can tolerate in actual service before deterioration sets in. In hydrodynamic lubrication, specific heat capacity is used in the determination of heat transfer, temperature rise and other thermal factors in oil [3].

Table 3. Chemo-physical properties of oil samples from mechanical pressing

	A_1	A_2	A_3	A_4	A_5
Odor	Mild	Mild	Mild	Mild	Mild
Color	Yellowish Brown	Light Yellow	Deep Yellow	Mild Yellow	Mild Yellow
Specific Gravity	0.870	0.912	0.906	0.909	0.909
Density, kg/m^3	870	912	906	909	909
°API	31.14	23.65	24.68	24.17	24.17
Cloud Point, °C	-5.5	9	8	7.5	7.5
Pour Point, °C	<-10	7	6.5	5	4.5
Flash Point, °C	180	350	280	290	320
Fire Point, °C	200	375	310	318	345
Oil Retention, %	12.40	40.05	15.12	8.32	22.57
pH	6.18	5.83	4.91	4.76	4.15
Specific Heat Capacity, $J/kg\ k^{-1}$	19500	6720.05	6756.30	4998.42	4410.02
Free Fatty Acids, %	1.96	5.61	4.49	5.05	5.19
Viscosity at 40°C, cSt*	64.57	78.97	84.49	78.71	75.03
Viscosity at 70°C, cSt*	48.43	50.36	72.83	67.46	57.72
Viscosity at 100°C, cSt*	32.24	39.42	44.75	52.47	40.24
Viscosity-Temperature Coefficient	0.50	0.50	0.47	0.33	0.46

cSt – centistokes (units commonly used in industry as opposed to NSm^{-2})

Table 4. Chemo-physical properties of oil samples from solvent extraction

	B_1	B_2	B_3	B_4	B_5
Odor	Mild	Mild	Mild	Mild	Mild
Color	Yellowish Brown	Light Yellow	Deep Yellow	Mild Yellow	Mild Yellow
Specific Gravity	0.85	0.89	0.84	0.88	0.88
Density, kg/m^3	850	890	840	880	880
˚API	34.99	27.49	36.95	29.30	29.30
Cloud Point, ˚C	-7	9.0	7.0	7.5	80
Pour Point, ˚C	<-10	6.0	5.5	5.0	4.5
Flash Point, ˚C	180	352	280	291	320
Fire Point, ˚C	200	374	305	320	349
Oil Retention, %	12.38	40.51	15.19	7.69	22.57
pH	6.18	5.90	4.99	4.85	4.10
Specific Heat Capacity, J/kg k^{-1}	19500	6726.3	6888.6	5000	4437.7
Free Fatty Acids	1.98	5.23	4.37	5.00	5.20
Viscosity at 40˚C, cSt*	62.10	75.66	82.69	75.04	74.15
Viscosity at 70˚C, cSt*	46.30	56.36	68.31	67.09	57.68
Viscosity at 100˚C, cSt*	31.18	39.08	40.63	52.53	39.95
Viscosity-Temperature Coefficient	0.50	0.48	0.51	0.30	0.46

cSt – centistokes (units commonly used in industry as opposed to NSm^{-2})

Free fatty acids for natural oils fall within a range of values normally higher than that of mineral base oils [15]. High values of percentage free fatty acids obtained for yellow oleander and other natural oil such as gmelina oil (37.49%), rubber oil (50.33%) and palm oil (39.47%) stands them out as good boundary lubricants [14]. This is due to formation of metallic soaps between surfaces in contact with the oil [13].

Viscosity is by far the most significant property for establishing the thickness, pressure and temperature of an oil in hydrodynamic and elastohydrodynamic lubrication [3]. The viscosities obtained for the oil samples shown in Tables 3 and 4 fell within the range of 84.48 cSt at 40°C and 32.24 cSt at 100°C for both types of oil samples. The viscosity of yellow oleander oil was within the range of standard oil lubricants (60cSt at 40°C and 24cSt at 100°C and can be upgraded to obtain function-specific viscosities.

The lower the viscosity-temperature coefficient, the higher the viscosity index of oil. Viscosity-temperature coefficient, an indication of the change in viscosities with temperature for the oil samples is shown in Tables 3 and 4. The difference between values shown in Tables 3 and 4 may be attributed to the different extraction processes. The values obtained for the yellow oleander oil and its blends compare favorably with results obtained for the reference oil. It was observed that the viscosity-temperature coefficient obtained with the two extraction methods where approximately the same (0.50). Therefore, processing methods of yellow oleander oil does not seem to affect the viscosity-temperature coefficient [14].

4. CONCLUSION

Oil was extracted from yellow oleander seeds and evaluated for lubrication performance. The extraction methods used did not affect the chemo-physical properties obtained for the oil. The functional properties obtained experimentally in this work for yellow oleander oil is within the range of standard oil lubricants. Yellow oleander has a remarkably high flash and fire points. The viscosity and flash points of the oil are adequate for application as a hydrodynamic oil lubricant in actual service. It can therefore be considered for use in transmission and gear train lubrication. It may also be used for lubrication of rollers, cams and journal bearings. On account of its fire point, low free fatty acids, specific heat capacity and pour point, it can be used as a hydraulic, brake and transformer oils. The oil has high oil retention property which makes it suitable for use in sealed ball and roller bearings in low-medium load applications. When upgraded, this oil may be used for high load ball and roller bearings. This, like other natural oils is suitable for marine applications as it is environment-friendly and biodegradable.

COMPETING INTERESTS

Authors declare that there are no competing interests.

REFERENCES

1. Gilman E, Watson D. *Nerium Oleander* – Oleander (*Fact sheet ST-412*). Gainesville, Florida, 1994. Hort.ufl.edu/database/documents/pdf/tree_fact_sheets/neroiea.pdf (assessed 20/12/2012)
2. Everest JW, Powe Jr TA, Freeman JD, Poisonous Plants of the Southeastern United States, Alabama Cooperative Extension system, 2005;1-59. www.aces.edo

3. Godfrey D, Herguth HR. Back to basics; physical and chemical properties of industrial mineral oils affecting lubrication. Parts 1-5. Society of Tribologists and Lubrication Engineers, Illinois. 1995. Available: http://www.stle.org/
4. Onukwuli OD, Okeke SI, Agbo GU, Ekumankama EO, Udeobi OO. Extraction, deodorization and saponification of rubber seed oil. NSE Transactions. 2000;35(1):5-11.
5. Satimehin AA, Akinremi OM, Ijabo OJ. Rheological behavior of palm oil. Science Forum: J Pure and Applied Sciences. 2003;2(6):291-297.
6. Alakali JS, Ijabo OJ, Satimehin AA. Rheological characteristics of canarium (Canarium Schweinfurhii) oil. Science Forum: J Pure and Applied Sciences. 2003;2(6):298-303.
7. Oseni MI, Nnuka EE, Ette AO. Rheological behavior of selected natural oils as alternative lubricants. J Metallurgy and Materials Engineering. 2005;2(1):27-33.
8. Ayoola PB, Adeyeye A. Effect of heating on the chemical composition and physico - chemical properties of arachis hypogea (Groundnut) seed flour and oil. Pakistan J Nutrition. 2010;9(8):751-754. Available: http://www.pjbs.org/pjnonline/fin1663.pdf
9. Martin JH, Leonard WH, Stamp DL, Waldren RP. Principles of Field Crop Production, 4th Ed, Prentice Hall, New Jersey; 2005.
10. Mc Cabe WL, Smith JC, Harriott P. Unit Operations in Chemical Engineering 7th ed. New York, McGraw-Hill Chemical Engineering Series; 2004.
11. David P, Cox HE. The Chemical Analysis of Food. 7 ed. New York. Churchill Livingstone; 1976.
12. Pitts SJ, Thomson CI. Analysis and classification of common vegetable oils. J Forensic Sci. 2004;49(5):1147. PMID: 14640273
13. Petro-Canada Lubricants. Lubricants handbook; 2011. Available: http://lubricants.petro-canada.ca/pdf/2011_Handbook_final_EN.pdf
14. Oseni MI, Nnuka EE, Ette AO. Evaluation of Chemo-Physical Properties of Selected Natural Oils Relevant to Lubrication. Nigerian J. Engineering Research and Development. 2006;5(2):1-9.
15. Foo-Yuen N, Foong-Kheong Y, Yusof B, Kalyana S. A renewable future driven with malaysian palm oil-based green technology. J. Oil Palm & The Environment. 2011;2:1-7.doi:10.5366/jope.2011.01. Available: http://www.iaee.org/en/publications/newsletterdl.aspx?id=75
16. Schulz J, Brinksmeier E, Meyer D. On the Interactions of Additives in Metalworking Fluids with Metal Surfaces. Lubricants. 2013;1:75-94; doi:10.3390/lubricants1040075 Available: www.mdpi.com/journal/lubricants Accessed: 10th September 2013.
17. Johnson DW, Bachus M, Hils JE.Interaction between Lubricants Containing Phosphate Ester Additives and Stainless Steels. Lubricants. 2013;1:48-60. doi:10.3390/lubricants1020048. Available: www.mdpi.com/journal/lubricants Accessed: 10th September 2013.

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