New Sources of Lubricants: A Study of Physicochemical Properties of Seed Oils from Arid Zone of Rajasthan

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***Abstract*: Lubrication is a phenomenon to introduce a substance between the moving contact surfaces to reduce friction. Lubricants are the substances applied for this purpose. Oil, grease, graphite, mineral oils are commonly used lubricants. These permits free action of mechanical devices, absorb excess of heat and prevents damage of machinery.**

A lubricant is used as around 90% of the base oil and rest of mineral oil. The additives are the chemical substances added to the lubricants to improve the quality. Mineral oils are being added for this purpose. Although these are cheap and available easily yet the oxidation products of these oils are not environmental friendly.

To overcome this problem searching of new sources of additives are in progress. The seed oils would serve a good option for it. High viscosity index, high flash and fire points, more biodegradability and oiliness are some of the advantages of these.

In the course of our research to seek new/novel sources of oils from Arid /semi-arid zone of Rajasthan, a number of seed oils were analysed. The physicochemical properties of seeds and oils have been determined using volumetric, spectroscopic and chemical techniques. A detailed field survey, seeds collection, oil extraction, and the determination of values like viscosity, acid values, saponification values and flash and fire points are some of the parts of research. Some edible oils were purchased from local market for comparative analysis. The various values were determined and compared for application in lubrication.

The present paper deals with the physicochemical analysis of *Vernonia cineria, Glycin max, Gossipium hirsutium, Verbesenia encelioides, Ricinus communis and Aracis hypogia seed oils*. It was concluded that these oils could prove their role better as compared to traditional additives.

***Key Words*: Lubricants, acid value, saponification value, viscosity index, arid-zone of Rajasthan**

I. INTRODUCTION

Machines are the integral part of development. Man had developed a number of machines to ease the lifestyle and to produce valuable products. The regular use of such machines results wear and tear, heat, loss of efficiency and many more effects. The problem of friction arises due to moving or sliding surfaces.

The introduction of a substance between the moving contact surfaces to reduce friction and to absorb heat is termed as lubrication. The substances applied for this purpose are called as lubricants. Generally oil, grease, graphite, mineral oils are used as lubricants. These permits free action of mechanical devices and prevents damage caused by abrasion. The unequal expansion caused by heat is also minimized by them. In mechanical processes lubricants also function as coolants to prevent heat-caused deformities. The science of friction, lubrication and wear is called tribology.

Application of proper lubricant allows smooth and continuous operation of equipment, reduces the rate of wear, and prevents excessive stresses at bearings. When lubrication breaks down, components can rub destructively against each other and cause heat, local welding, destructive damage and ultimate the permanent failure of the machine.

The traditionally used lubricants include around 90% of lubricant and 10% of the required additives. Mineral oils are common additives, which is colourless, odourless, light mixture of higher alkanes from a mineral source, like petroleum distillate. The mineral oil by itself having been used for many specific oils. Some common mineral oils are white oil, liquid paraffin, and paraffinic liquid, and liquid petroleum.

Mineral oil is produced in very large quantities and available in light and heavy grades.

The extraction, fractionation, storage and application of mineral oil have been reported as environmentally hostile. Some of the environmental problems are greenhouse effect, acid rain and global warming.[1-2]

One of the reasons for recent green initiative is the growing awareness and demand to use more environmentally safe products. The fact that petroleum-derived mineral stocks have finite resources has also created a pressing need to find alternative/renewable sources. By keeping these aspects seed oils have been introduced in the field of lubrication. The selection of proper effective oil for additive or as lubricant is based on its physico chemical properties. These are moisture content, fatty acid composition, iodine value, saponification value, acid value, ester value, amount of unsaponifible matter etc. The selection of a new oil as an additive in lubricant requires complete phytochemical profile which obtained from physical and chemical analysis. The present paper is related with some of these properties.

II. MATERIAL AND METHODS

2.1 Raw Material collection and processing:

The plants were identified and their seeds were collected from natural growing and cultivated plants.[1-6] , these were washed with water to remove dust and dirt particles. The cleaned seeds were dried in an oven at 60°C for 7 hours to reduce moisture content and were stored in air tight containers for analysis .The dried seeds were grounded in powder by Mortar and pestle into small pieces. Some oils were directly purchased from local market for comparison of values.

2.2 Determination of Physical Properties of the seeds [3-4]

a. Moisture content

40 g of seeds were taken in a silica crucible and dried in an oven for 7 hours at 80^0 C. The weight of crucible with seeds was recorded after every 2 hours using desiccators for cooling. The same procedure was repeated till a constant weight is obtained. The moisture content was calculated using the formula

$M\% = 100 (W_2\text{-}W_1)/M$

M%= moisture content

$W_{2=}$ weight of seeds + crucible before heating

$W_{1=}$ weight of seeds + crucible after heating

b. Determination of oil percentage

150 ml. of petroleum ether/normal hexane was taken in a round bottom flask. 30 g of crushed seeds were filled in a thimble. The apparatus was heated at 60^0C and 3 continuous extractions were taken. The same experiment was repeated with different amounts of samples and the weights of extracted oil were taken. From the average of these values the oil content was calculated.

2.3. Extraction of oils

Petroleum ether (300 ml. of 40-60^0C range of boiling point) was filled in a round bottom flask. 10 gram of crushed seeds was packed in a thimble and placed in the apparatus and allowed to heat at 60^0c for 30 minutes. The thimble was removed, dried in oven, cooled in desiccators and the weight was taken. This process was repeated to get the maximum extract. The same procedure was repeated with 5 g of sample seeds. After complete extraction the resulting micelle was taken for solvent recovery and the oil thus obtained was cooled and filled in a viol for further analysis.

2.4. Characterization of Extracted oils[5-11]

a. Boiling point of oil

The oil was heated on heating mantle to form the bubbles with inserting a thermometer in it. The temperature of oil was obtained as boiling point

b. Refractive Index

Adobe Refractometer was used to determine the refractive index of the oil at 30° C.

c. Specific gravity of the oils

Density bottle was used for specific gravity. The weight of empty 25 ml. capacity bottle was taken and filled with oil sample. The weight of oil and bottle was noted again. The same process was repeated with water as reference standard.

d. Determination of Saponification value [S.V.]

To determine the Saponification value of oils ISO 3657 (1988) indicator method [10] was applied. In this method 2g (M) of oil and 25 ml. of N/10 ethanolic KOH is added in a conical flask. It was heated using a reflux condenser for 1 hour. 2-3 drops of phenolphthalein indicator was mixed to warm mixture and titrated against M/2 HCl (N).At the colourless solution, the volume of HCl used was noted as V_1 .The same steps was repeated with blank solution and volume was noted as V_0. Saponification value S.V. was calculated using the following formula.

$S.V. = 56.1\ N\ (V_0\text{-}V_1)/M$

e. Determination of Acid Value [A.V.] [12]

10 g (W_0) of oil was filled in a 250 ml conical flask and a few drops of phenolphthalein indicator were mixed to it. 25 ml of diethyl ether + 25 ml of ethanol mixture was added to it. The mixture was titrated against M/10 NaOH with continue shaking to get a dark pink color at volume of NaOH [V_0] .The free fatty acids [FFA] were calculated as

$FFA=2.82\text{x}100\text{x}V_0/W_0$

The acid value = FFA/2.

f. Determination of Iodine value [I.V.]

The Iodine value of the oils was determined by ISO 3961 (1989) method [11]. 0.4 g oil (M) was taken into a conical flask with 20 ml. of carbon tetra chloride. 25 ml. of Dam's reagent was added in fume chamber. It was stopped and swirled vigorously. It was placed in dark for 2.5 hours and 20 ml of 10% aqueous KI and 120ml of water were added. These contents were titrated against M/10 sodium thiosulphate solution to get a pale yellow solution. 1% starch indicator was added to get blue color. It was again titrated till disappearance of blue color (V_2 ml). The same procedure was repeated with the blank solution (V_1ml). The iodine value (I.V.) was calculated by the expression:

I.V. $=12.69C\,(V_1-V_2)/M$

g. Determination of Viscosity

The viscosities of oil samples were determined by Redwood viscometer no.1 and no.2 .50 ml of oil was allowed to flow through orifice. The time to flow of oil is noted in redwood seconds. Different readings were taken at a temperature range.

h. pH of the oils

2g oil and 13ml of hot distilled water were mixed in a clean dry beaker and stirred slowly. This mixture was kept in a water bath to decrease the temperature at 25^0C. The pH electrode was standardized and the electrode immersed into the sample and pH value of sample was recorded.

III. RESULTS AND DISCUSSION

Table: 1. Identification of plants

Sp no.	Common name	Botanical name	Family
1	vernonia	Vernonia cineria	Asteraceae
2	soybean	*Glycin max*	Leguminoceae
3	Cotton	*Gossipium hirsutium*	Malvaceae
4	Yellow top weed	*Verbesenia encelioides*	Asteraceae
5	khimp	*Leptadenia pyrotechnica*	Asclepidiaceae
6	castor	*Ricinus communis*	Euphorbiaceae

Table 2. Properties of seeds

Species no.	Moisture content[%]	Oil content [%]	Oil appearance
1	4.22	25.78	Clear transparent
2	0.55	46	Clear transparent
3	4.35	20	yellowish
4	4.33	31.21	Yellowish, specific smelling
5	2.11	12	Pale yellow, specific sweet smelling
6	1.00	36	Colourless, viscous

Table 3. Properties of oils

Sp.	R.I.	S.G	S.V.	I.V.	C.P. [^{0}C]	P.P. [^{0}C]
1	1.470	0.890	193	125	-5	-9
2	1.488	0.924	191	130	1	0
3	1.490	0.926	195	130	0	-9
4	1.499	0.946	165	165	-5	-9
5	1.467	0.917	196	196	3	1
6	1.536	0.961	181	85	-7	-32

The moisture content, oil percentage and oils appearance are shown in Table-2. The moisture in the matured seeds was found as 0.55 to 4.35% which is a result of different climates and storage media. The oil content was found as 12-36% in the selected samples. The variations results due to variety, environmental and climatic conditions, also on the mode of extraction.

Table 3 represents the physicochemical properties of seed oils. The refractive index of oils were found in the range of 1.467 to 1.536 at 25^0C .The specific gravity of oils ranges from o.890 to 0.961. Saponification values (mg KOH/g of oil) were calculated from 181 to 196 in the selected samples. The Iodine values (g I_2/100 g of oil) ranges 85 to 196.The cloud points and pour points [^{0}C] of oils were found in the range of 3 to -7 and 1 to -32 respectively.

IV. CONCLUSION AND SCOPE

The percentage of oil in all the selected seeds were more than 10%, which is quite satisfactory for industrial cultivation. Since all the oils are non-drying oil so it can be used at room temperature in various fields. Lubrication additives is most emphasised in the current paper. These oils would also be applied in manufacturing of soap. The yield of seeds and their oil percentage are affected by environmental conditions, variety and age of plant, collection timings, storage etc. To improve yield and quality these parameters could be controlled.

A number blends may be formed to study combined effects and a better formulation could be achieved. In addition all the selected plants belongs to arid/semiarid climate so their exploitation would be more promising. Moreover it would also serve non edible oils for industrial demands and save the edible ones for human consumption.

The above studies concludes that vegetable oil-based environmentally friendly lubricants are dual objectives to fulfil. One is environmental safety and the other is the quest for alternatives to petroleum base stocks. The future of these classes of lubricants will greatly depend on overcome of some minor disadvantages while these are competitive in price.[12]

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