S2

RAW MATERIALS DEVELOPMENT FOR INDUSTRIAL APPLICATIONS

BY

DR. S.T. WARA & DR. F.K. HYMORE

1. **ABSTRACT**

Studies on the electrical properties of several locally available vegetable oils have strong similarity between their properties and those of the transformer oil used for comparison purposes. Appropriate treatment of the oils gave oils of higher break down voltages than that of the transformer oil. The results also showed the dependence of the result on the percentage FFA content of the oils.

Further studies requiring the use of highly refined oils (very low FFA) in actual operation are necessary. These will test the stability of the oils during actual performance and serve to confirm the promise shown by these renewable raw materials.

INTRODUCTION

Raw materials are an essential ingredient for technological growth. Growth in technology initiates the creation of industries – cottage industries. These industries may carry out maintenance, monitoring, manufacturing, producing, innovating etc. The paper considers oils as essentials in high powered devices viz machines, switchgears, components (capacitors) etc.

1.1 AIMS AND OBJECTIVES

The aims and objectives of this paper is to enhance the use of vegetable oils in the electrical industry for the optimal use of oils – vegetable oils.

1.2 OILS – TYPES AND FUNCTIONS

Many types of oils exist with their origin emanating from different sources. Generally, vegetable oils have been used for domestic purposes (cooking) and for industrial purposes (soap manufacture, lubricants, coolants etc). The sources of oils can either be renewable (viz vegetable oils – groundnut oil, coconut oil, palm kernel oil, rubber seed oil etc) or non-renewable – petroleum oils. Mineral oils obtained from petroleum have found use in many electrical applications as well being major source of raw material, and finished products in the chemical industry. It also serves a major source of energy and lubricants. Oils of animal and vegetable origin have been more confirmed to the food industry with numerous applications than mineral oils in the chemical industry inspite of the use of soaps, cosmetics and alkyd resins. But the big advantage of the vegetable oils viz groundnut oil, palm oil, coconut, palm kernel oil etc) is the fact that they are renewable unlike the mineral oils.

1.3 OILS AND TRANSFORMERS

Power and distribution transformers are tanked in oil. The oil serves as a medium for heat transfer (coolant) and insulation reinforcement (insulant). Presently the oil used is from a petroleum source which is non-renewable. Also the cost of transformer oil is reasonable high (about ₦15,000.00/drum). In other to perform this double role, the oil must satisfy certain chemical and electrical properties as listed in Table I.

Technological development encourages short term, medium term and long term plans for proper assessment of existing and new systems. Materials development focuses

on sources that are renewable. Vegetable oils satisfy this renewablility and the potentials are enormous. Work has been done and further work is in progress to use vegetable oils in place of transformer oils, future plans are to use such oils for breakers, motor car engines, and any other transmission oils.

1.4 METHOD OF DEVELOPMENT

Vegetable oils were sourced and subjected to various chemical and electrical analysis in their raw (untreated) forms as well as in their treated (refined) forms. The aim is to investigate such oils vis-à-vis any standard transformer oils in a bid to match such oil's properties with the standards qualifying the petroleum oil as a transformer oil.

1.5 HISTORICAL DEVELOPMENT

Prof. P.A. Kuale investigated the electrical properties of oil in 1978 and concluded that the breakdown voltage of such oils are better than that of transformer oil.

Also a Ph.D. work was carried out on palm kernel oil in the University of Ife.

In 1987 Dr. F.C. Obi & Ekeh J.C. investigated vegetable oils for purity and breakdown strength.

From 1990 – 1995 Dr. S.T. Wara worked on coconut oil investigating its electrical property and use in a prototype distribution transformer. On companing its performance chenacteristic vis-à-vis a control prototype of similar rating in transformer oil concluded that it is useable.

Six other students have furthered the work on oils to further investigate the chemical, electrical properties and the stability of vegetable oils.

1.6 RESULTS FROM VARIOUS STUDIES

All studies on the electrical properties of different vegetable oils - groundnut oil, soya bean oil, cocoa nut oil, palm kernel oil and palm oil (often fraction) – showed strong similarities between their properties and those of the transformer oils. Tables 3 and 4 give such results for degummed, neutralized and dried groundnut oil and olein (fraction of palm oil).

Breakdown voltages higher than that of the transformer oil were obtained for both oils. These values are within the range required for mineral oils used as dielectric – see Table I. The results however show a strong dependence of the breakdown voltage of the oils on their percentage free fatty acid content (FFA). The different treatments given an oil sample in general resulted in oils of different %FFA.

Table 4 gives results of an olein which had been repeatedly refined to obtain an oil of lower %FFA than the transformer oil studied for comparison purposes. The %FFA of the oils also affected the relative values of other dielectric properties as well – dielectric constant dissipate factor etc. Other physical properties such as specific gravities and viscosities of the oil are within the same range as that of the transformer oil. The higher flash point, fire point and smoke point of the vegetable oil makes it safer to use.

The encouraging results lead one to the following:-

- use oils of the lduert FFA content possible in further studies.

- to use such oils in actual performance studies in order to study the stability of the oils – tendency to sludge formation, changes in percentage FFA etc. The use of anti oxidants will thus be necessary in the next phase of study.

1.8 ADVANTAGES OF THE WORK

The source of vegetable oils is renewable. Vast espance of unprofitably uncultivated land exist. Feasibility studies into prospecting for vegetable oils will yield certain results. This is not the case with petroleum propecting. The scope of use of vegetable oils as alternatives is inexhaustible.

1.9 CONCLUSION

The authors encourage adaptive technology in the management of existing systems especially in this era of raw materials scarcity, high prices, unnecessary time lags, high down times etc. However financial constraint have reduced the pace of this work which will bring unlimited benefits to the generality of the human race.

APPENDIXES

TABLE 1: **PROPERTIES OF A TYPICAL MINERAL OIL**

PROPERY	UNIT	VALUE
Density at 15° C	Kg/m^3	880
Viscosity at 37.8°C	mm^2/s	10
Boiling Range	°C	170-200
Evaporative loss at 110°C	%	0.7
Flash Point (closed)	°C	149
Pour Point (max)	°C	-31
Sludge Value	%	0.8
Acidity	GKOH/Kg	0.01
Breakdown Voltage (r.m.s)	KV	45-70
Relative Dielectric Constant (at 60Hz)		2.1
Dissipation Factor (at 60Hz)		0.1
Coefficient of Cubic Expansion /°C		0.008
Specific Heat	J/Kg/K at 15°C at 80°C	1900 2200
Thermal Conductivity	W/Mk	0.15

Table 2: **TYPICAL PROPERTIES OF TRANSFORMER OIL**

PROPERTY	UNIT	VALUE
Pour Point	°C	-40
Flash Pont	°C	132
Fire Point	°C	149
SpecificGravity (at 15.6°C)	Gkm3	0.91
Viscosity (at 37.8°C)	Cst	63
Dielectric Strength	KV/mm	25

Note: Dielectric strength a high value is an indication of freedom from moisture and impurity.

Table 3: **EXPERIMENTAL RESULTS USING GROUNDNUT OIL**

PROPERTY	UNIT	VALUE
Breakdown Voltage	KV	54 (NGO); 48 (TFO)
Dielectric Strength	KV/mm	21.7(NGO); 19a2 (TFO)
Dielectric Constant (at 60Hz)		2.45(NGO); 2.27 (TFO)
Dielectric loss tangent (60Hz)		0.001 (NGO), 0.0012 TFO
Dielectric loss factor (60Hz)		0.002 (NGO) 0.003(TFO)
Dielectric Conductivity (60z)		0.080 NGO 0.088 TFO

NGO = Groundnut oil which has been neutralized by alkali treatment and dried

TFO = Dried transformer oil.

Table 4: **EXPERIMENTAL RESULTS FROM OLEIN FRACTION OF PALM OIL**

PROPERTY	UNIT	VALUE
Acidity	MgKOH/kg	Olein/TFO 0.0298/0.0597
Flash Point	°C	142/140
Fire Point	°C	160/158
Specific Gravity (60 °C/25 °C water)	-	0.9005/0.9082
Viscosity	(cst)	9.30/10.10
Breakdown Voltage	KV	54.2/51.4
Dielectric Strenght	KV/mm	21.9
Dielectric Constant (at 60Hz)		0.0215
Dissipation Factor (at 50Hz)		0.014

REFERENCES

1. Kirk Othmer, "Encyclopedia of Chemical Technology, Vol.13, 3rd Edition, A Wiley - Interscience Publication (1981), pp 537 – 551.

2. Say, M.G., "Electrical Engineer's Referume Book, Butterworth & Co (Rulhtims) Ltd., London; 1973, pp 4 – 63.

3. Pender, H: "Electrical Engineers' handbook, (Electric Power), Del Mar, A.W., 4th Edition, John Miley & Son Inc., N.Y. (1949), pp 10 – 45."