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THE DIELECTRIC STRENGTH OF INDIAN VEGETABLE OILS

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INTRODUCTION

India is rich in vegetable oils. It is being felt that their physical and electrical properties should be carefully investigated with a view to ascertain whether they can be suitably substituted in place of mineral oils, which are used as insulants for various electrical purposes, especially in transformers, oil switches and oil-filled condensers and cables.

Their physical properties such as viscosity and gas absorption at different temperatures, their electrical properties such as d.c. conductivity and dielectric constant are being studied in this laboratory by other workers. The present authors have, however, begun a series of investigations on their dielectric strength (or electric breakdown), dielectric loss and power factor measurements.

In the present paper are reported the preliminary results obtained on the electric breakdown of as many as fourteen samples of Indian vegetable oils and the influence of moisture content on their breakdown voltages.

EXPERIMENTAL

For preliminary investigations it was thought fit to test the breakdown voltages of the oils according to the method prescribed in the B.S. Specification No 148, 1927. Tests have been performed with both a.c. and d.c. voltages impressed on the oils. The a.c. voltage was obtained from the secondary of a G.E.C. step-up voltage (220V/20,000V) transformer, the primary circuit being controlled by an auto-transformer. The control of the high-voltage circuits is shown in the circuit diagram, Fig. 1.

For tests with d.c. voltage a Kenetron rectifier was used in the secondary circuit of the H.T. transformer. A resistance of about 40,000 ohms was used in the high-tension circuit during the tests. The voltage across the cell containing the oil under test was measured with the help of an electrostatic voltmeter (0—25/50/100 KV). The frequency of the a.c. supply was maintained constant at 50 cycles per second. The wave-form of the supply voltage was sinu-

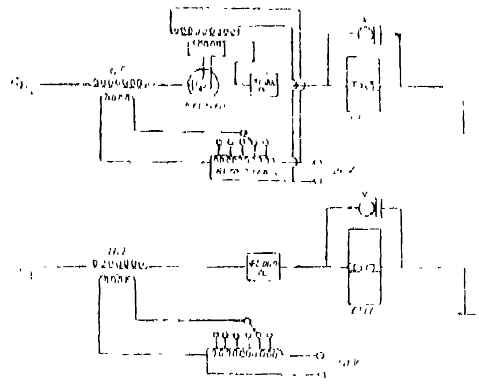

FIG. 1

soidal, the crest value being therefore 1.45 times the R.M.S. value as measured by the electrostatic voltmeter.

The oil container is made of a thick-walled glass vessel of internal dimensions 55 mm. × 90 mm. × 100 mm., according to specification. Two circular holes are made on the two opposite walls of the vessel to allow the spherical electrodes to pass through them. The electrodes are brass spheres of 13 mm. diameter, each being screwed up to a small stainless steel shaft with a terminal screw outside and held in position by means of collars such that the spherical electrodes remained perfectly horizontal. One of the electrodes is fixed while the other is made movable by a sliding adjustment of the shaft through a guide. The guide is provided with two slots having an interval of exactly 4 mm. (or 0.157 in.). When the fixing pin on the movable shaft is put in the first slot, the two spheres just touch each other, but when it is removed to the second slot, they are separated exactly by 4 mm.

The electrodes and the cell were thoroughly cleaned and dried before test on each oil was carried out.

The oil under test was initially heated slightly above the room temperature (to about 40°C.) and stirred in a vacuum chamber for several hours to remove the moisture already present in the oil and to drive out the dissolved air in it. It was then cooled down to the room temperature in the same chamber. A volume of about 300 c.c. was introduced into the previously cleaned cell. The final purification, *i.e.*, removal of dust and fibres, which might be present as suspended impurities, inspite of its being filtered by means of a stream-line filter, was done electrically. The cell was filled with the oil under test and a voltage of 10 KV across the electrodes was applied for thirty seconds, thus subjecting the oil to a voltage gradient of 25 KV per cm., so that all the dust particles and fibres might be attracted by the electrodes. The electrodes were washed clean by pouring over them some fresh oil. This operation was repeated several times at the beginning of each test.

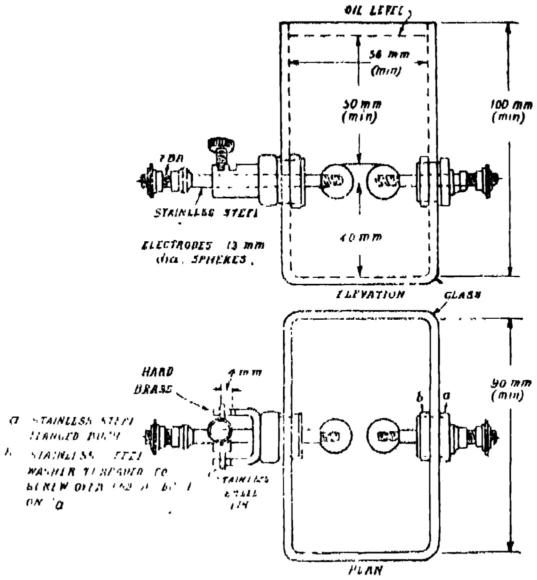

FIG. 2

TABLE I

Temperature = 30°C. Barometric Pressure = 75·32 cm.

Name of oil tested	Preliminary arcing formed at KV/cm. (R.M.S.)	Max. a.c voltage applied per cm (R.M.S.)	Remark
Castor oil	·	47·50 KV	No breakdown
Cocoanut oil	—	47·50 ,,	,,
Mohua oil	—	46·50 ,,	,,
Cotton Seed oil	—	46·50 ,,	,,
Rape oil	40·00	47·50 ,,	,,
Rayona oil	42·80	47·50 ,,	,,
Arachis oil	37·50	46·50 ,,	,,
Wood oil	30·00	46·50 ,,	Breakdown
Kapok oil	15·00	48·75 ,,	No breakdown
Punag oil	—	46·50 ,,	,,
Neem oil	37·50	48·75 ,,	,,
Chalmugra oil	—	48·75 ,,	,,
Linseed oil	—	47·75 ,,	,,
Sesame oil	40·15	48·75 ,,	,,

Voltage was then applied in gradual steps to the cell containing the purified oil. At each step the impressed voltage was sustained for at least one minute. Similar tests were performed with d.c. voltage of the same range. The results of these observations are given in Tables I and II.

TABLE II

Temperature = 31°.5 C. Barometric Pressure = 75.50 cm.

Name of oil tested	Preliminary arcing formed at KV/cm (d.c.)	Max. d.c. voltage applied per cm.	Remark
Castor oil	-	48.50 KV	No breakdown
Cocoanut oil	45.00	46.50 ,,	,,
Mohua oil	—	46.50 ,,	,,
Cotton Seed oil	—	47.50 ,,	,,
Rape oil	40.00	47.80 ,,	,,
Ravona oil	37.50	48.50 ,,	,,
Arachis oil	42.80	46.50 ,,	,,
Wood oil	30.00	45.00 ,,	Breakdown
Kapok oil	45.00	47.50 ,,	No breakdown
Punag oil	—	47.50 ,,	,,
Neem oil	37.50	48.75 ,,	,,
Chalmugra oil	—	48.75 ,,	,,
Linseed oil	—	47.50 ,,	,,
Sesame oil	40.00	48.75 ,,	,,

To study the effect of moisture on the breakdown voltage, the oil was dried and purified electrically as before. A known quantity of distilled water was added to a measured volume of the oil and shaken vigorously and stirred before being filled in the cell. Sufficient time was allowed for the air-bubbles to clear out from the oil adjacent to the electrodes. The test voltage was then gradually applied, carefully noting the effects produced thereby. The moisture content was gradually increased. The breakdown voltage was noted at each step. A few typical curves showing the relation between breakdown voltage and the percentage of moisture content for two of the oils studied are given in Fig. 3. The data for these curves are included in Table III.

It was further observed that when any impurity is introduced into the oil under test, the breakdown voltage diminishes. Such observations have already been made by several authors in the case of mineral oils.

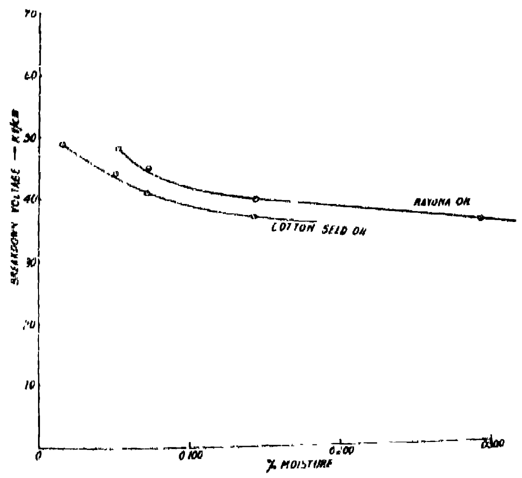

FIG. 3(a)

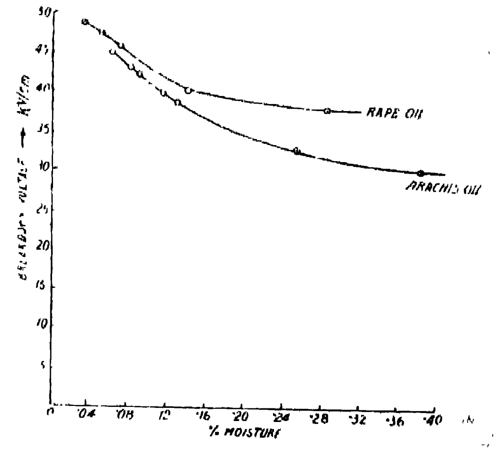

FIG. 3(b)

TABLE III

Temperature = 30°.5 C. Barometric Pressure = 78.5 cm.

Cotton Seed Oil			Rayona Oil		
% of Moisture	Arcing voltage in KV per cm. (R.M.S.)	Breakdown voltage in KV per cm. (R.M.S.)	% of Moisture	Arcing voltage in KV per cm. (R.M.S.)	Breakdown voltage in KV per cm. (R.M.S.)
0.0000	—	—	0.0000	37.50	—
0.0055	—	—	0.0071	32.75	—
0.0150	37.50	—	0.0143	30.00	—
0.0200	37.50	—	0.0214	30.00	—
0.0250	35.00	48.75	0.0280	30.00	—
0.0550	32.25	47.50	0.0357	30.00	48.75
0.0724	30.00	46.50	0.0500	30.00	46.50
0.1428	20.00	37.50	0.0714	25.00	45.25
—	—	—	0.1428	20.00	40.00
—	—	—	0.2856	12.50	37.75

Our conclusion regarding the suitability of these oils as insulants is reserved till our study of their physical and other electrical properties is complete.

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