CHAPTER IV

SURFACE CHARGE STUDIES OF ELECTRETS PREPARED FROM TWO PLANT PRODUCTS

General.

In this chapter the surface charge studies of electrets prepared from two plant products from (i) Boswellia Glabra and (ii) Vateria Indica are described. The investigations in the previous chapter indicate that the properties of electrets mainly depend upon the nature of the material used for their preparation. As the work done so far on electrets is still not extensive it was decided to investigate more substances for the electret phenomenon. After preliminary attempts, the above two plant products were found to be fairly suitable material for electret preparation. The characteristics of electrets prepared from these materials have not been investigated so far by any one. For the sake of convenience, this chapter is divided into two parts. In part I, the studies on "Boswellia Glabra" electrets are given, and in part II those on "Vateria Indica" electrets are given.
PART I

CHARGE STUDIES OF ELECTRETS
PREPARED FROM "BOSWELLIA GLABRA"

(i) Introduction.

The material used in this part is a plant product like the carnauba wax. This resinous substance from Boswellia Glabra is known as the Indian Olibanum, Indian Frankincense or "Koonthrekum" in the native language, Malayalam (1, 3 & 4). This incense bearing Boswellia Glabra is a tall erect tree covered with greenish ash-coloured bark which peels off in papery flakes, popularly grown in India in the Coromandal mountains and the Deccan. This large tree affords good timber also. A fragrant, transparent golden-yellow resin oozes out from the cuts on the bark of this tree which soon becomes hard and brittle. The tapping of the tree is usually commenced in November and carried on till June and stopped during monsoon. Throughout this period the "freshening" is carried out every fourth or fifth day by removing a thin shaving of $\frac{1}{2}$ inch to 1 inch of the bark from the upper edge to the lower edge of the original girdle. A tree generally yields 2 to 4 lbs. of resin in a year (5).

There are two varieties of this gum-oleoresin,
one of which is far inferior to the other. The best variety which is used in this work is found in pieces as large as walnut, of a high yellowish colour, inclining to red or brown, covered on the outside with a white powder. It burns with a clear and steady light, not easily extinguished and diffuses a pleasant fragrance. In taste it is slightly bitter and pungent and not perfectly soluble in water or alcohol. However, it is soluble in ether and spirits of wine. The resin is burnt as an incense in the religious ceremonies of Hindus and also in Roman Catholic Churches.

This gum-resin is used in the preparation of Ayurvedic and Yunani medicines in India. This is specially useful in the treatment of skin and blood diseases, fevers, dysentery, diabetes, jaundice etc. It is an internal and external stimulant. It is also recommended in combination with other drugs for the treatment of snake-bite, scorpion-sting and also in rheumatism (1, 2 & 3).

The chemical and physical properties of this plant product are not known completely. However, it has been reported (4) that the crude resin consists
of the following ingredients:-

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential oil</td>
<td>8-9%</td>
</tr>
<tr>
<td>Rosin</td>
<td>55-57%</td>
</tr>
<tr>
<td>Gum</td>
<td>20-23%</td>
</tr>
<tr>
<td>Insoluble matter</td>
<td>4-5%</td>
</tr>
<tr>
<td>Moisture</td>
<td>10-11%</td>
</tr>
</tbody>
</table>

Fowler and Malandkar, Simonsen etc. (6, 7, 8) have given a method of removal of the essential oil from the crude resin and the approximate constituents of the oil.

(ii) **Experimental Procedure.**

Sufficient quantity of yellowish pieces of this plant product were selected for the preparation of electrets. These pieces were dried properly in the sun and then powdered in a mortar. It was light yellowish in colour. This powder was passed through a 100 mesh sieve. It did not show a definite melting point. However, most of the ingredients of the material were found to be in a molten state at about 120°C.

Every time a little quantity of this well-mixed and sieved powder was taken in a small beaker and melted over an electric heater. The electrode
assembly was also heated a little above 120°C. The molten substance was then poured into the mica slot of the gadget. When the material began to solidify, the heated upper electrode was placed over it. The extra material was squeezed out on all the four sides of the upper electrode which in turn was removed by means of a piece of blade. The upper electrode was clamped to the casket by means of clamping device. Then the casket was placed inside an oven, which was adjusted to give a constant temperature. When the electrode assembly and the material had attained the temperature of the oven, the high tension was applied for the required time by means of the 5 KV Ionisation Tester. After formation, the electret was taken out. It was short-circuited and kept in desiccator. The charge measurements were carried out as described earlier in the case of carnauba wax electrets.

With this plant product, a series consisting of 25 electrets were prepared at 25 different temperatures in the range from 30°C to 150°C in steps of 5°C. Polarising field (10 KV/cm), time (8 hours) and thickness (1.0 mm) were kept constant for all the electrets in this series. The charge measurements were carried out for more than a month in each case and decay curves were plotted for
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1B8C30</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>30°C</td>
</tr>
<tr>
<td>2</td>
<td>2B8C35</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>35°C</td>
</tr>
<tr>
<td>3</td>
<td>3B8C40</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>40°C</td>
</tr>
<tr>
<td>4</td>
<td>4B8C45</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>45°C</td>
</tr>
<tr>
<td>5</td>
<td>5B8C50</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>50°C</td>
</tr>
<tr>
<td>6</td>
<td>6B8C55</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>55°C</td>
</tr>
<tr>
<td>7</td>
<td>7B8C60</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>60°C</td>
</tr>
<tr>
<td>8</td>
<td>8B8C65</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>65°C</td>
</tr>
<tr>
<td>9</td>
<td>9B8C70</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>70°C</td>
</tr>
<tr>
<td>10</td>
<td>10B8C75</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>75°C</td>
</tr>
<tr>
<td>11</td>
<td>11B8C80</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>80°C</td>
</tr>
<tr>
<td>12</td>
<td>12B8C85</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>85°C</td>
</tr>
</tbody>
</table>

(cont'd on)
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Electret No.</th>
<th>Thickness of the Electrets</th>
<th>Polariising Voltage (in KV)</th>
<th>Polariising Field (KV/cm)</th>
<th>Polariising Time</th>
<th>Polariising Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>13B8C90</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>90°C</td>
</tr>
<tr>
<td>14</td>
<td>14B8C95</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>95°C</td>
</tr>
<tr>
<td>15</td>
<td>15B8C100</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>100°C</td>
</tr>
<tr>
<td>16</td>
<td>16B8C105</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>105°C</td>
</tr>
<tr>
<td>17</td>
<td>17B8C110</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>110°C</td>
</tr>
<tr>
<td>18</td>
<td>18B8C115</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>115°C</td>
</tr>
<tr>
<td>19</td>
<td>19B8C120</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>120°C</td>
</tr>
<tr>
<td>20</td>
<td>20B8C125</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>125°C</td>
</tr>
<tr>
<td>21</td>
<td>21B8C130</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>130°C</td>
</tr>
<tr>
<td>22</td>
<td>22B8C135</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>135°C</td>
</tr>
<tr>
<td>23</td>
<td>23B8C140</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>140°C</td>
</tr>
<tr>
<td>24</td>
<td>24B8C145</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>145°C</td>
</tr>
<tr>
<td>25</td>
<td>25B8C150</td>
<td>1.0 mm.</td>
<td>1.0 KV</td>
<td>10 KV/cm</td>
<td>8 hrs.</td>
<td>150°C</td>
</tr>
</tbody>
</table>
studying their characteristics. The details of this series of electrets are given in Table No. 22.

(iii) Results and Discussions.

The decay curves for the series of electrets prepared from "Boswellia Glabra" at different temperatures have been shown in Figs. 173 to 197. A detailed study of these curves shows the following important characteristics. Heterocharge appears both on anode and cathode sides of all the electrets irrespective of the polarising temperature. The magnitude of this heterocharge is found to be comparatively smaller at lower temperatures than at higher temperatures. The initial heterocharge is fairly high, especially in between the temperatures 100°C to 125°C. Maximum heterocharge, however, was found to be 20.4 esu/cm² at 125°C. Initial charge in most of the cases is found to be above 10.0 esu/cm². This initial charge generally reverses to homo within a day or two. Then the homocharge reaches its maximum value within a comparatively shorter period (one or two days) and thereafter it slowly decays to the saturation value in about 10 to 15 days. An exception, however, is found in the case of electret No. 12 Bg Cg5 as shown in Fig. 184. The heterocharge on both the sides of this electret took a longer period for reversal. The retentive capacity of homocharge
of the electrets prepared at lower temperatures is comparatively poorer than those prepared at higher temperatures, as is to be expected.

The relation between the final charges after 30 days and the polarising temperatures is shown in Fig.198. The nature of this curve reveals the following features. Electret with moderately good charge (4.2 esu/cm²) can be prepared even at room temperatures (about 30°C). It also shows that the final charge increases with increase in polarising temperatures up to 110°C and the linear nature of the curve indicates that the increase of charge is proportional to the polarising temperature. The curve slopes down rapidly with further increase of temperature. This denotes an adverse effect in the electret formation at very high temperatures specially near about the melting point and above it. This result, however, is found to be in accord with the results obtained in the case of carnauba wax electrets. It may be noted that most of the ingredients of the electret material are in a molten state above 110°C and at 110°C the wax becomes soft. The rapid diminution of the final charge in between the temperatures 110°C and 130°C is probably due to the higher thermal motions of the molecules and ions and the consequent disturbing influence on the
inner and outer polarisations. It is also likely that some of the constituents of wax might have decomposed. After 130°C the rate of reduction of the final charge with increase of polarising temperature is found to be very slow. The maximum value of homocharge is found to be near about 11.0 esu/cm² at 110°C.

These results lead to the following conclusions:

(a) The plant product from Boswellia Glabra is a very suitable material for the preparation of electrets, better than many other substances investigated so far including carnauba wax.

(b) There exists an optimum polarising temperature at which the electrification of the electret is maximum and the electret prepared at that temperature consequently shows steady characteristics.

(c) For consistency and formation of maximum final charge, the simultaneous presence of strong hetero and homocharges are found to be essential.

(d) The decay curves of the anode and cathode sides show more or less the same general characteristics in all the cases. The magnitude of the charges on either side, however, is found to be slightly different in all the cases.
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Figs. 173 - 176)
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Figs. 177 - 179 & 192)
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Figs. 180 - 183)
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Figs. 184 - 187)
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Figs. 188 - 191)
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Figs. 193 - 196)
Curves Showing The Charge Decay Of 'Boswellia Glabra' Electrets Prepared At Different Temperatures

(Fig. 197)

Final Charge After 30 Days And Polarising Temperature Of 'Boswellia Glabra' Electrets

(Fig. 198)
PART II

STUDIES IN ELECTRETS OF THE PLANT PRODUCT
FROM "VATERIA INDICA"

(i) **Introduction.**

In this part, another plant product, i.e. from 'Vateria Indica', has been used as the material for the preparation of electrets.

*Vateria Indica* (Linn.) is a large, resinous, evergreen tree with whitish bark and white fragrant flowers. It is found in Western India, in the forest of Western Ghats from North Kanara to Travancore and Tinnevelly at elevations up to 4000 feet. Often it is planted as an avenue and shade tree. This particular tree is also known as Indian Copal tree or White Dammer tree in English or Payanjor Telli in the native language Malayalam (1, 2, 3 & 4).

This tree yields the piney-gum resin, an excellent varnish resembling Copal. It is produced by cutting a notch in the tree, sloping inwards and downwards, from which the resinous juice runs and is soon hardened by exposure to the air. The bark is wounded in the beginning of the dry season. The resin begins to flow within three or four days and continues flowing for two to three months. The congealed resin
is collected. This oleo-resin is known as white dammer or piney varnish or Indian Copal. It is said to occur in three forms: (i) Compact piney resin which is hard, in lumps of varying shapes, bright orange to dull yellow in colour, having a glossy fracture and resembling amber in appearance, (ii) Cellular piney resin which occurs in shining masses varying in colour from light green to yellow or white, and (iii) dark-coloured piney resin which occurs in pockets in old decayed trees. In general it is found from pale green to deep amber colour with all the intermediate shades (4).

This oleo-resin is very useful in the preparation of a varnish along with camphor and alcohol. It is also used in the preparation of candles on the Malabar Coast which diffuses an agreeable fragrance and also gives a clear light and little smoke. The gum is useful for varnishing anatomical preparations. The best specimens of the gum are employed as ornaments under the name Amber (Kehroba) to which it bears exterior resemblance.

The resin of Vateria Indica is used medically also. It is good for certain throat diseases and chronic bronchitis, boils, piles, ulcers, diarrhoea, tuberculosis, etc. The gum boiled in oil can be applied in rheumatic swelling of the joints. Under the influence
of gentle heat, the resin combines with wax and oil and forms a good substitute for the official resin (1, 2 & 3).

The chemical and physical properties of this plant material is not reported so far.

(ii) **Experimental Procedure.**

For the preparation of electrets, reddish-brown coloured pieces of this resin were selected. These pieces were powdered in a mortar and then melted in a beaker. The material was maintained near about 110°C for some time and filtered through glass wool. This melting and filtering processes were repeated two more times to remove the impurities present in the material. Finally the solid substance was broken into pieces and again powdered finely in a mortar to pass through 100 mesh. Every time a small quantity of this uniform powder was taken in a small beaker and melted for the preparation of the electret. This material did not show any definite melting point as it is not a definite chemical compound. However the substance was found to be softened at about 90°C and in a molten state, at about 97°C.

The preparation, preservation, measurement of charge of the electret etc. were similar to those
Table 23
Details of the Series of Vateria Indica Resin Electrets Prepared at Different Temperature

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Electret No.</th>
<th>Thickness of the Electrets</th>
<th>Polaris-ing Volts</th>
<th>Polaris-ing Field</th>
<th>Polaris-ing Time</th>
<th>Polaris-ing Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 VgC40</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>40°C</td>
</tr>
<tr>
<td>2</td>
<td>2 VgC50</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>50°C</td>
</tr>
<tr>
<td>3</td>
<td>3 VgC60</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>60°C</td>
</tr>
<tr>
<td>4</td>
<td>4 VgC70</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>70°C</td>
</tr>
<tr>
<td>5</td>
<td>5 VgC80</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>80°C</td>
</tr>
<tr>
<td>6</td>
<td>6 VgC85</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>85°C</td>
</tr>
<tr>
<td>7</td>
<td>7 VgC90</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>90°C</td>
</tr>
<tr>
<td>8</td>
<td>8 VgC100</td>
<td>1.0 mm.</td>
<td>1.2 KV</td>
<td>12 KV/cm</td>
<td>8 hrs</td>
<td>100°C</td>
</tr>
</tbody>
</table>
adopted for carnauba wax and other electrets.

With this material, a series of eight electrets were prepared at different temperatures by varying the temperature from 40°C to 100°C. The details of this series of electrets are given in Table No.23. For all the electrets in this series, the polarising field (12 KV/cm), polarising time (8 hours) and thickness of the electret (1.0 mm) were kept constant. Observations were taken for one month in each case and the decay curves were plotted for studying the characteristics.

(iii) Results and Discussions.

The decay curves for the series of Vateria Indica-resin electrets are shown in Figs.199 to 206. The initial charge in almost all the electrets is hetero which eventually reverses to homo. This homocharge in the first instant reaches maximum in a few days and then decays to a permanent value within 10 to 12 days. Both the anode and the cathode sides show the same type of general behaviour.

The curve in Fig.207 shows the final charges after 30 days and polarising temperatures for the above series of electrets. It can be seen from this curve that the final charge increases steadily with the polarising temperature up to about 90°C. Increase
of temperature above 90°C shows little reduction in
the final charge value. Hence for Vateria-resin electrets,
90°C is found to be the most suitable polarising temperature
at which the electret formation gives its maximum effect.
The softening point of this material starts at about 90°C.
Therefore these results are also in accord with the
results discussed in the previous sections.

This curve also indicates that the charges
at low temperatures are comparatively poorer than those
at higher temperatures. It also shows that the value
of the final charge is low at all polarising temperatures
comparing to Boswellia-resin electrets and carnauba
wax electrets. The maximum charge in this case at
90°C is only about 2.6 esu/cm², which is only 1/5th
of the value obtained under similar conditions for
Boswellia-resin electrets. This again indicates the
influence of the electret material on the formation
of electret.
Curves Showing The Charge Decay Of 'Vateria Indica' Electrets Prepared At Different Temperatures
(Figs. 199 - 202)
Curves Showing The Charge Decay Of 'Vataria Indica' Electrets Prepared At Different Temperatures

(Figs. 203 - 206)

Final Charge After 30 Days And Polarising Temperature Of 'Vataria Indica' Electrets

(Fig. 207)
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