CHAPTER V

PHOTO - ELECTRICITY
5.1 INTRODUCTION

In the second chapter, we have studied the properties of thermo-electret of β-Naphthol. Thermo-electrets were prepared by subjecting the samples to thermal treatment along with d.c. electric field. It was found that the life of these thermo-electrets was in hours. If the thermal treatment is replaced by photo excitation, the electrets are to be said photo-electrets. In 1937, Nadshakov (1,2,3) discovered this new type of electret effect. He worked on the polycrystalline sulfur and found that charges were retained for a long time after the illumination has ceased and the applied electric field was removed. Polarisation of the sample was estimated from the initial value of the discharge current. Increasing the time interval between the measurement of charge by depolarisation at the end of polarisation process. It was found that polarisation produced in this
manner could be retained for a long time in darkness. This time was 16 hours for pure crystalline sulfur. Photo-electrets of polycrystalline sulfur exhibited a stable hetero-charge and no change of photo-electret polarity was observed.

The mechanism of photo-electret is strongly related to the phenomenon of photoconductivity. The internal photo-effect (photo-conductivity) was discovered by W. Smith (4) in 1873. The photo-conductivity of sulfur was discovered in 1889 by Vorob'ev (5).

Polarisation during photo-conduction was discovered in the early studies of the photo-conductivity of dielectrics. It was first described by Goldman and Kalandykh (6) who found decaying polarisation photo-currents in polycrystalline sulfur as well as discharge currents on illumination in the absence of an external field.

During photo-conduction, the polarisation in sulfur was observed by Kurrelmeyer. After the polarisation electrodes were short circuited, the sample (crystal) was illuminated again and a discharge current was observed which eventually decayed to zero. The density of charge was less than $4 \times 10^{-12}$ coul/cm$^2$. Kurrelmeyer did not determine how long this charge was retained.

Man'kov (7) also worked on polycrystalline sulfur in the absence of an external field. Discharge currents were observed by him after intervals of time varying from 5 min to 98 hours from the end of polarisation.
Tartakovskii and his co-workers (8-14) studied the energy bands and levels in crystals. It was helpful to understand the nature of the residual polarization produced during photo-conduction in dielectrics.

Coloured NaCl and KBr crystals were studied by Tartakovskii and Kaminker (12) and Kaminker himself (13). First maxima in the depolarization current spectrum of NaCl (at $\lambda_1 = 465 \text{ m}\mu$) was due to electrons transmission to the conductance band from the F- centre levels and the second (at $\lambda_2 = 485 \text{ m}\mu$) due to the transition from the F' center levels related to inhomogeneities near the electrode.

Photo-electret studies dealt mainly with polycrystalline dielectrics but it was found (16,16,17) that the photo-electret state may occur also in many monocrystals and monocrystals have their importance in crystal physics. The necessary conditions for the establishment of the photo-electret state in monocrystals and the depolarization of the monocrystalline photo-electret by illumination are separate problems. The dependence of the photo-electret charge on the polarizing field and temperature is of special interest. Depolarisation of crystals by illumination should be studied at various temperature. Further points of interest are the dependence of the photo-electret charge on the duration of polarisation and on the irradiance and the mechanism of depolarisation by illumination.

Beside the sulfur, NaCl & KBr crystals, other mono and polycrystalline dielectrics like Anthracene (17), oxides of
titanium and Germanium, Barium titanates (18), poly-crystalline Zn, Se (19) and phosphors like CdS and ZnS have been studied. The best of these materials were (Zn: Cd) S phosphor and anthracene. They are both capable of sustaining polarisation field gradients of more than 1000 volts /cm. for long periods of time and furnish output potential for above 100 volts. The creation and discharge of these polarisation are highly radiation sensitive. The work was done by Fridkin and Zheludev on the monocrystals of phenanthrene, chrysene, cinnabar and in amorphous selenium.

The phenomenon of polarisation in photo-conducting materials is known under the name "Persistent Internal Polarisation (P.I.P.)". As far as the mechanism is concerned persistent internal polarisation comes in existence by the displacement of free charges inside the material and their subsequent localisation in deep traps. A requirement for persistence is that the free charges disappear fast after the polarising field is removed, otherwise charges would tend to discharge the produced polarisation spontaneously. Thus photo-conducting materials are polarizable while they are irradiated with any kind of radiation or shortly after as long as free charges may exist. After removing free charges by infrared quenching the polarizability by field alone no longer exists. Electro-luminescence materials are also polarizable because of the creation of free charges by the application of electrical fields. The spontaneous decay of polarisation comes about by the motion of the remaining free charges in the internal polarisation field. This shifts the charges in such a direction as to annul the polarisation. If practically no free charges persist
polarisation still decays spontaneously when charges bound in shallow traps, which evaporate into the conductivity band. Thus a condition for strong, long persistent polarisation is a large number of deep traps and only a small number of shallow traps. In agreement with these considerations, the materials K and anthracene were the best substances for polarisation. They also show the faster decay of photo-current and light emission after the excitation is removed.

Fact must also be borne in mind when the decay of polarisation is considered. The total amount of free charges required to cancel the polarisation is larger than the polarisation charge itself.

Removal of polarisation occurs by the creation of free charge by any kind of radiation. They move in the internal field to cancel the polarisation. This removal of polarisation charge can be accelerated by the application of removal field.

The possibility of utilizing photo-electrets in electro-photographic process was pointed out by Fridkin, Fomon and Nemirovskii in 1960 (20). The discovery of the use of photo-electrets in electrophotography and the subsequent investigation led to a new approach to the photo-electret state in dielectrics.

6.2 DURATION OF DETENTION OF INTERNAL POLARISATION IN PHOTO-ELECTRET

Conditions of polarisation greatly affect the life period of photo-electrets and these conditions give the information
on the formation of the photo-electret state in dielectrics (15, 17, 21, 22, 24).

Short circuiting effect also occurs in photo-electrets. This effect was found in thermo-electrets, which has already been discussed in chapter III. Kallman and Rosenberg (17) noted that it is necessary to store photo-electrets in dry air or in a desiccator. Nadzhakov and Kashukeev (15) worked on polycrystalline and monocrystalline sulfur and found that the duration of the retention of photo-polarisation and the decay of this polarisation with time, depend on the purity of the specimen and on the thermal conditions during the various treatments. Life period of photo-electret of pure "Kahlbaum" polycrystalline sulfur was found nearly 37 hours and the same life time was obtained in the case of photo-electret of commercial purified polycrystalline sulfur. The decay of photo-polarisation in sulfur monocrystals has been reported faster than in polycrystals (16).

The decay can be represented by the equation

$$P_0 - P = at^n$$

where $P_0$ is the initial value of the photo-electret polarisation, $P$ the polarisation at any time $t$, where $a$ and $n$ are constants. Kallman and Rosenberg found that decay of photo-electret does not depend only on the nature of dielectrics but it depends on thickness of the sample, intensity of polarising field and the nature of illumination used during polarisation.

In the case of dark depolarisation of photo-electret of anthracene, (ZnS(e)) and electro-luminescent ZnS, two distinct stages were
obtained by Kallman and Rosenberg. In the first stage polarisa-
tion decayed very rapidly and in the second stage, the polarisa-
tion decayed slowly over a long time. Strong polarisation was
found in photo-electret of polycrystalline anthracene after one
month's storage in darkness. Photo-electret of (ZnS:Cr)S retained
60% of its initial charge 100 hours after the polarisation, experi-
mental data show clearly that the nature of illumination affected
the decay. The residual polarisation in photo-electret was found
to increase with polarising voltage and the sample thickness.

Internal polarisation in monocrystalline and poly-
crystalline sulfur and in monocrystalline anthracene was studied
by Fridkin, Zheludev et.al. (21, 22, 23). It was found that after
50 hours in darkness, the polarisation of the sulfur monocrystal
decayed practically to zero. The sulfur polycrystal retained 40%
of its initial polarisation after 90 hours.

Golovin, Kasmekeev, orlov and Fridkin (24) studied
the dark depolarisation of electro-luminescent zinc sulphide. The
dark polarisation of ZnS was due to localization of electrons at
shallow levels. In one hour it decayed practically to zero. The
photo polarisation was found from the difference of the total
polarisation and its dark polarisation. Photo-polarisation decayed
rapidly first then a "saturation effect" was observed due to the
localization of electrons at deeper levels.

In the case of mono-crystals of sulfur and anthracene,
decay of polarisation in darkness obeys an exponential law.

\[ \sigma = \sigma_0 e^{-t/\tau} \]  

(8.2)
The relaxation time $\tau$ was found to be greater for anthracene than for sulfur.

Photo-electret state was found also in phenanthrene, cinnabar and other mono-crystals. The reported results were qualitative. In all these crystals, the dark depolarisation reduced the polarisation to zero.

The dark depolarisation reduces the photo-electret charge to zero in the case of monocrystals of sulfur and anthracene. On the other hand in the case of polycrystalline photo-electrets a stable internal polarisation is produced. This polarisation reaches a constant non-zero value or whether it finally decays to zero can be settled only by measurement over very long time interval.

Results may be explained on the basis of trapping of electrons at local levels in polycrystalline and mono-crystalline samples. It is possible that the initial rapid decay of polarisation of polycrystals in darkness represents the liberation of electrons from shallow levels, while the subsequent slow decay is due to the liberation of electrons from deeper levels, therefore it may be assumed that a stable residual polarisation in polycrystalline photo-electrets is due to the localization of electrons at the deepest levels, related possibly to grain boundaries.

5.3 **FORMATION OF THE PHOTO-ELECTRET STATE IN DIELECTRICS AND THE RECIPROCITY LAW**

Polarisation $P$, of a photo-electret depends on the
duration of polarisation \( t \) and obeyed the following empirical law

\[
P = P_{\text{max}} \left( 1 - e^{t/\tau} \right)
\]  

(5.3)

The factor \( P_{\text{max}} \) shows the saturation effect during the formation of the photo-electret charge. This effect was reported also by Man'kov (7). The dependence of the magnitude of polarisation produced in photo-electret of anthracene and (Zn : Cd)S on the duration of polarisation was studied by Kallmann and Rosenberg (17). But they did not study the reason of saturation effect. In the case of anthracene, it was found that, if the irradiation was reduced the time necessary to achieve a given polarisation increased. If the time of polarisation is increased to infinity the same polarisation value will be obtained which would be independent of irradiation.

Kallmann and Rosenberg (17) studied also the dependence of the polarisation of an anthracene photoelectret on irradiation and found the dependence is approximately logarithmic. Fridkin (21) worked on monocristalline sulfur and studied the dependence of polarisation on the irradiance and on the duration of illumination. The results showed the dependence of the initial direct photocurrent on the irradiance. An increase of the duration of illumination beyond about 5 minutes does not produce any further rise of the residual polarisation. The total polarisation of a sulfur monocristal is pointless because all polarisation decays to zero.

Studies done by many workers on the photoelectret state in dielectrics (17, 26) showed that the dependence of the photo-
electret charge on the irradiance and on the duration of polarisation, is governed by the nature of the dielectric and by the conditions of polarisation, in particular wave-length of radiation used. The empirical dependence of the photo-electret charge on the duration of polarisation given by the eqn.(5.3), is not frequently obeyed. The departure from the reciprocity law depend on the nature of dielectrics and its conditions of polarisation. Departure from the reciprocity law in monocrystalline anthracene was reported by Belgaev, Golovin and Fridkin (23). The photo-electrets made of anthracene using $\gamma$-rays (23) obeyed the reciprocity law.

Electro-luminescent zinc sulphide was studied by Orlov (26). The dependence of polarisation on the duration of polarisation at various irradiance, was found in similar manner as in the case of sulfur, anthracene and (Zn:Cd)$_2$. A characteristic saturation was obtained on increase of the duration of polarisation.

According Kallmann and Rosenberg (17), the saturation effect may be due to the filling of only a small fraction of the free levels with electrons. This idea was confirmed by the studies of the dependence of photo-electret charge on the polarising field intensity in many dielectrics.

In the case of sulfur monocrystal, no saturation was observed with fields up to 20 $\text{KV/cm.}$ although the conditions were favourable for saturation. This confirms that during formation of a photo-electret, there is only a partial filling
of levels with electrons. The saturation effect is not due to complete filling of all traps in a crystal but is related to the kinetics of the electron conditions.

In the case of electro-luminescent the study of dependence of photo-electret charge on the applied field was studied by Kashukeev (15). No saturation effect was observed in the study of dependence of the photo-electret charge on the polarising field intensity in any dielectric except polycrystalline CdS. This means that the photo-electret state in dielectrics is due to the filling of only a small proportion of the traps with electrons.

Kallmann and Rosenberg (17) studied the dependence of photo-electret state as a function of wave-length of illumination used during polarisation. Some photo-polarisation was also observed in the case when illumination with wavelength longer than absorption of light by activator's atoms in (Zn:Cd)S, which produces electron transition from the activator levels to the conduction band.

Anthracene and (Zn:Cd)S also exhibit a strong fluorescence when excited with visible light. Kallmann and Rosenberg suggested that the fluorescence may be partly reabsorbed and this would contribute considerably to the total polarisation.

5.4 GENERAL METHODS OF MEASURING THE PHOTO-ELECTRET CHARGE:

In both the cases of thermo-electret and photo-electret, charge density and its decay with time has to be
measured. Thus the methods which have already discussed in the chapter III can be used in the study of photo-electrets.

Nedzhakov prepared the photo-electrets of sulfur and used a similar method as used by Groetsinger for thermo-electrets (27). Nedzhakov and Kashkeev (18) used a similar apparatus to that as used in Nedzhakov's earlier work (1,2). The sample was polarised by simultaneous illumination and application of an electric field. At the end of polarisation treatment, both electrodes were grounded and photo-electret was kept in the dark for certain time. One electrode was connected to the input of an electrometer and the photo-electret was illuminated. Depolarisation takes place causing a discharge current to flow in the external circuit. Initial value of the depolarisation current was taken as a measure of the photo-electret charge.

Fridkin and Zheludev (21,22,28) used a similar method and vacuum-tube electrometer was used in the measurement. The sample was placed in a special thermostat in which the sample could be illuminated with a horizontal light beam (parallel to the polarisation). The discharge current produced by the second illumination was measured as a function of time. The discharge current integrated with respect to time and the total charge librated could be found.

The lifted electrode method which has been described in detail in chapter III, was used by some workers (15,17). Hallmann and Rosenberg (17) measured the photo-electret charge
both with the lifted electrode and by depolarisation method.

5.5 Present Method

In the present investigation, lifted electrode method was used to measure the charge density, life time and mode of decay of photo-electret of β-Naphthol.

(A) Lifted Electrode Method

This method has been discussed in chapter III with details. The circuit diagram is shown in fig. (5.1). Only the charge measuring assembly is replaced by a new assembly which was prepared in the workshop. The details of the charge measuring assembly and the method of charge measurement are given below. Lindemmann electrometer was used as a measuring device. The description of the construction and the way of working, calibration etc. have already discussed in the chapter III.

(a) Charge Measuring Assembly

The assembly works on the principle of electrostatic induction method. The charge of the sample is transferred on the lifted electrode through induction and then recorded on the measuring device instrument. The sample rests on a fixed electrode. The lifted electrode is adjusted first in the contact of the sample. Both electrodes are short circuited through a key. The lifted electrode is connected to Lindemmann electrometer needle through a key simultaneously as the lifted electrode is raised short circuit must be broken at the time of measurement.
This assembly consists a metallic cubic hollow box with dimension of one feet. A portion of area 4" x 4" cut out for a window from a vertical side for the convenience of inserting the source of excitation. Source of excitation placed at the bottom. A lens system is arranged in the vertical direction and in the middle of the box. A threaded rod is adjusted along a vertical wall of the box which helps to giving the motion to lens with cut inserting the hand in side. A small circular portion is cut out at the centre of top level. The box is painted black inside and polished. So that there is no reflection of light.

Another small cubic box is adjusted at the centre on the top. A metallic filter or a conducting glass plate used as lower fixed electrode and is adjusted at the circular hole of big box. A lifted electrode is a copper rod, which is threaded at both ends. At lower end, it carries a aluminium circular electrode and on second end it is screwed with a ebonite handle. Two springs are provided on the each side of small box in the lifted electrode. The connection of the both electrode are taken on the body of small box through shielded wire and there is no electric communication between the electrode and the body of box. The diameter of the lifted electrode is \( \text{3.5 cm} \). The lifted electrode can be adjusted in any position with the help of screw.

Both the electrodes are short circuited through a wax key as desired. The whole body of this assembly is shown in fig. (5.2).
Fig. 5.2 - Charge Mannerism Assembly.
Method of charge measurement:

A sample of β-Naphthol is taken between the fixed and lifted electrode of charge measuring assembly and an D.C. field is applied on the sample. The polarity can be changed with the help of double way key. After the polarisation of sample for certain period, the D.C. field is cut off and sample is short circuited through the key. Lindemann electrometer is connected to the power supply. Adjustment of mechanical and electrical zero and the sensitivity are made as discussed in chapter III. Now the lifted electrode is lifted and connected to the electrometer. The earthing of the needle and the short circuit of fixed and lifted electrodes is broken at the time of measurement. Induced charge is recorded by the deflection of needle. When the sample is out of measurement, both electrodes are short circuited. Lindemann electrometer is calibrated separately thus with the help of calibration curves, charge density of polarised sample can be calculated in coul/cm² or in e.s.u.

To see the effect of excitation the sample is polarised in the absence and in the presence of any radiation. To measure the charge density at anode and cathode the sample is polarised under the both-conditions, once when the lifted electrode is working as anode and once, when lifted electrode is working as cathode. To investigate the mode of decay, the charge density was measured after each five minutes for an hour.

A 60 watt milky bulb and aluminium foil were used as a source of excitation in this method.
5.6 **DETAILS OF MEASUREMENTS**

Photo-electrets were prepared, under different fields with different polarizing time and in the presence of two different sources of excitation. The above said photo-electrets were prepared with the point of view to see the following effects.

(a) **Field and time effect.**
(b) **Affect of the intensity of source of excitation.**
(c) **Investigation of the mode of decay.**

(a) **Field and Time Affects:**

To study in details the effect of field and time on β-Naphthol photo-electrets, seven series each consisting of five samples were prepared under the field .55, 1.1, 1.6, 2.2, 2.8, 4.4, 5.5 KV/cm. Samples were polarised for 1,3, 5, 10 minutes under each field. To see the effect on both +ve and -ve polarity, two similar series were prepared one for +ve polarity and other for -ve polarity. Other preparative parameters were remained constant throughout the investigation. The effect of field and time was investigated in terms of surface charge density.

(b) **Affect of Intensity of Source of Excitation:**

Photo-electrets series (5.6(a)) were polarised in dark, in the presence of ordinary light (60 watt milky bulb) and in the presence of aluminium arc. Charge density was measured to see the effect of the source of excitation.
(c) Investigation for the Mode of Decay:

In order to study in detail the mode of decay of charge of photo-electrets, the charge density was measured at intervals of five minutes for an hour. The charge density was measured on both positive and negative polarities for every photo-electret to see the nature of decay of charge on both polarities.

In all the above investigations thickness of the sample and the electrode material were kept constant. Conducting glass was used as lower electrode, because the sample was to be excited from the lower side and aluminium electrode was used as the upper electrode. Both faces of the photo-electret were short circuited when it was out of investigation.

6.7 Results:

Electrets were prepared under the field .55, 1.1, 1.6, 2.2, 2.8, 4.4, and 5.0 KV/cm. Separate samples were polarised for 1, 3, 5, and 10 minutes under different fields. Each series of electrets was polarised in the dark, in the presence of ordinary light (60 watt milky bulb) and in the presence of aluminium arc. Charge density was measured on both the polarity for an hour at interval of five minutes. Some results are given here which are shown in graphs fig. No. (5.3 - 5.14). The conclusions drawn from the observations and graphs are given below:

(a) No charge reversal was obtained in any case.
(b) Hetero charge was obtained in each case and on both the polarities.
F = Field.  
T = Time of Polarisation.  
P = Polarity.  
D = Darkness.  
O = Ordinary light (excitation source).
F = Field  
T = Time of Polarisation
P = Polarity  
D = Darkness  
O = Ordinary light (excitation source)
<table>
<thead>
<tr>
<th>Field</th>
<th>Time of Polarisation</th>
</tr>
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<tbody>
<tr>
<td>P</td>
<td>Polarity</td>
</tr>
<tr>
<td>O</td>
<td>Darkness</td>
</tr>
<tr>
<td>O</td>
<td>Ordinary light (excitation source)</td>
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</tbody>
</table>

**Figure 5.5** Decay mesh of photo-electric response

- F: Field
- T: Time of Polarisation
- P: Polarity
- O: Darkness
- O: Ordinary light (excitation source)
F = Field,  T = Time of Polarisation,  P = Polarity,  D = Darkness,  0 = Ordinary light (excitation source).
$F = \text{Field}$  $T = \text{Polarizing time}$
$P = \text{Polarity}$  $D = \text{Darkness}$
$G = \text{Ordinary light (excitation source)}$
$A = \text{Aluminium arc (excitation source)}$

**FIG. 5.7** Decay mode of photo-electric.
FIG. 58 Drawings of Photo-electric

| F = Field       | T = Polarising time. |
| P = Polarity    | D = Darkness         |
| O = Ordinary light (excitation source) | A = Aluminium arc (excitation source) |

30 = Ordinary light (excitation source)
FIG. 5.10 Decay mode of photo-electric

F = Field   T = Polarizing time
P = Polarity   D = Darkness
G = Ordinary light (excitation source)
A = Aluminium arc (excitation source)
FIG. 5.12. Decay mode of Photo-etcher

F = Field           T = Polarising time
P = Polarity        D = Darkness
O = Ordinary light (excitation source)
A = Aluminium arc (excitation source)
FIG. 5.14. Decay mode of photo-electric

Charge Density in Coulombs

Time in Minute

F = 5.0kV/cm
T = 3 minutes
P = +VC
D = 1
A = 3

Legend:
F = Field
T = Time in Minutes
P = Polarity
D = Distance
A = Ordinary Light (unlighted source)
X = Molecular pro. tem. light source

[Diagram showing decay curves with labels and values]
(c) Mostly the surface charge density becomes constant after 60 to 60 minutes.

(d) Just after the preparation of photo-electret, a large value of charge was obtained in each case, which fell to lower value within five minutes.

(e) Decay was regular, but some time charge becomes constant after five or ten minutes for 10 or 15 minutes.

(f) No statement can be made regarding the relationship between the charge density and time, during which the sample was polarised and between the charge density and the field under which the sample was polarised.

(g) Charge density on the both +ve and -ve polarities was obtained in the order, Charge density (aluminium arc used as the source of excitation) Charge density (60 watt milky bulb used as the source of excitation) Charge density (in dark).

5.8 DISCUSSION:

Phenomenon of photo-polarisation in photo-conducting materials was observed earlier by Nadzhakov (1, 2), Hilsch (29), Hughes (30), Fowler (31) and Kallmann (18) and Goldman (32). Photo conduction is a necessary condition for the formation of the photo-electret state.

In the present investigation a sample of β-Naphthol was polarised under the field .55, 1.1, 1.6, 2.2, 2.8, 4.4 and
5.0 KV/cm. The sample was polarised for 1, 3, 5 and 10 minutes for every field in the dark and in the presence of ordinary light (60 watt milky bulb) and aluminium arc. The charge density was measured for one hour at an interval of five minutes on the both +ve and -ve polarity. A clear difference appears in the density of charge as

\[ D_{\text{Aluminium arc}} > D_{\text{Ordinary light}} > D_{\text{Dark}} \]

It becomes clear that the photo-electret state can be maintained in β-Naphthol. As far as the effect of time and field, no definite conclusion can be drawn at least from the present study. In the lack of ohmic contact, it is not possible to detect the small changes. Photo-effect were found 1000 times greater in magnitude when the sample was taken in the form of thin film than in the case of pellet form of the sample. The mechanism of stable polarisation is not the same in the two type of electret (i) photo-electret (ii) thermo-electret.

Hetero-charge has been obtained throughout the present investigation and no change of photo-electret polarity was observed. The growth of hetero-charge is due to the internal polarisation. The cause behind the absence of homo-charge seems that the charge carrier did not spread in the volume of dielectric due to the solid phase of β-Naphthol. As the study was done at room temperature and as such a weak internal polarisation was possible. In the present case the applied field did not exceed 5.0 KV/cm. This field is not sufficient to ionise the air gap between the electrode and sample.
Nadzhakov and Kashkeev (16) reported the formation of homo-charge in monocristalline sulfur photo-electrets when these crystals were polarised at sufficiently high temperature.

When the field is applied, barrier polarisation develops in which the charge injected from the electrode collect near the electrodes. \( \beta \)-Naphthol is a polar substance to some extent and dipole oriented in the direction of field, may contribute to the hetero-charge formation. The phenomenon discussed so far is obtained in dark polarisation. The effect of illumination was to increase the value of hetero-charge. There are two possibilities which the illumination seems to produce, one is on the electrode and other is in dielectric itself. Rosenburg and Kallman (13) confirmed with the help of some data that photo-electrets are produced both when a dielectric was in contact with its electrodes and when the electrodes were insulated from the dielectric by mica spacers. The second possibility seems to a rise of hetero-charge.

Absorption of photons creates the charge carriers. It means, photons give sufficient energy to electrons and they become free and mobile. The free charge carriers are separated by the effect of external field. There seems to be a partial trapping of carriers, otherwise they will recombine after the removal of field and excitation. The charge carriers of both type hole & electrons are shifted towards the respective opposite electrode. This separation of charge carriers and their trapping produce hetero-charge. Kallman (13) and Hofstadter (33) support
this mechanism. The persistence of the polarisation will, in any case, depend on the persistence of the electrons in traps.

In short the internal polarisation effects are described in terms of the frozen-in charge distribution. The build up of polarisation occurs during external field application while the sample is in a state of excitation. This separation persists after excitation and field removal because of trapping process.

In the study of conductivity and thermo-electret, the presence of shallow traps in the β-Naphthol has been assumed. The nature of deep traps in amorphous organic dielectrics has been the subject of considerable speculation. There is some evidence that microcrystalline regions provide shallow traps (31). However there seems to be no direct correlation between crystallinity in dielectrics and capacity for electret formation.

The higher value of hetero-charge in the case when aluminium arc was used as a source of excitation than that of the case of ordinary light is due to the presence of ultraviolet in excess in the aluminium arc. The energetic photons of ultraviolet produce more charge carrier in the dielectric and the number of trapped charge carriers become more in this case.

In the lack of suitable different sources of excitation and due to experimental difficulties, this study could not be extended. The pellet form of the sample has also not been found so suitable for the study of photo-conduction and photo-polarisation in detail.
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