Electric conduction mechanisms of PS-PMMA blend film pure and doped with salicylic acid.

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Abstract :

The electrical conduction mechanism in (PS Polystyrene) (PMMA) Polymethylmethacrylate blend film, pure and doped with salicylic acid has been studied at various temperatures in the range 323K to 363 K. The results are presented in the form of I-V characteristics. Analysis has been made in light of Poole-Frenkel, Fowler-Nordheim, Schottky, log (I) Vs T Plots and Arehenius plots. It is observed that, Schottky Richardson mechanism is primarily responsible for the observed conduction

Ketywords : (PS) Polystyrene, (PMMA) polymethylmethocrylate, (SA) Salicylic acid.

Introduction :

Electrical conduction mechanism in i-odine-doped polystyrene (PS) and polymethyl onethacrylate (PMMA) has already been reported [i], Belsare and Deoganokar [2] have reported the increase in electrical conductivity of PS and PMMA with the increase in iodine doping concentration.

Conductivity due to electrons excited from valence band to conduction bond in case of organic solids, is higligible [3], a complex conduction behavior [3,4] has been explained usually in terms of electron emission from cathode, i.e. Schottky-Richardson mechanism [5] or by electron liberation from the traps on the bulk of the material, i.e. Poole-Frenkel mechanism [6]. The possibility of tunneling or fowler. Nordheim mechanism [7], space charge limited conduction [8] etc. Have also been investigated in the literature. The possibility two or more molecules can be realized through the choice of proton. Donor and proton acceptor polymers [9]. In the present study DC-conduction through blend film pure and doped was studied to indentify the mechanism of electrical conduction. It is shown how the 1-v data of the sample can be used to arrive at possible conclusions. Results have been discussed in the light of different mechanism.

2) Experimental :

The film was prepared by isothermal evaporation technique [10]. The thickness of film was measured by digital micrometer (Mitutoyo corporation, Japan). These films was kept between the electrodes of specially designed sample holder. The current I and voltage (V) measurements have been recorded at various constant temperatures by using Keithley 6487 picoammeter cum voltage source instrument.

Result and Discussion :

The log 1-log v plots of the sample at various temperatures323 k, 333k, 353 k, 363 k are shown in fig.1. The current increases linearly with the applied voltage and follow power law, $I=KV^m$, where K and m are constants.

Fig (1) log I Vs log V

Fig (2) log 6 Vs c

The increase of current with voltage is rather weaker at low values of voltages and gets increases at higher voltages. From Fig 1 it is clear that i) Current at constant temperature increases with applied voltage and ii) Current at constant applied voltage increases with temperature. The mechanism suitable in the present case is discussed in the light of the following mechanism.

3.1 Poole – Frankel Mechanism:

The Poole-Franked relation [6] for current density is

$$J= \quad B\exp\left[\frac{-\psi}{KT} + \beta_{pF} E^{1/2}\right] \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

$$\text{where } B_{PF} = \frac{e}{KT}\left[\frac{e}{\pi E E_0 d}\right]^{1/2} = \text{Const.}$$

and e = electronic charge which predicts a field – dependent conductivity as

$$\log 6 = \log 6_0 + B_{pF} /2kT \; E^{1/2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

So that the Poole-frenkel mechanism is characterized by the linearity of log 6 vs E plots with a positive slope.

In the present case of PS and PMMA blend film pure & doped with salicylic acid the log 6 vs E plots are linear but with a negative slope (figure 2) indicating the absence of PF mechanism.

3.2 Flower – Nordheim mechanism :

The F N relation [7] for current density J can be expressed as

$$\log \frac{J}{v^2} = \log A = \left(\frac{\psi}{v} \right) \qquad \text{……………..(3)}$$

and long J/v^2 vs 1/v plot is expected to be a linear relation with a negative slope.

In present case log J/v^2 vs 1/v plot for the sample is presented in fig 3. Excepting few points, which have strayed away, the graphs are nearly straight lines with positive slope, indicative of the absence of tunneling current as is suggested by f-N mechanism.

3.3 Schottky Plots

Thermal activation of electron, may occur over the metal-insulator interface barrier, which is further helped by the applied electric field effect, which reduces the height of the barrier. The Schottky-Richardson current voltage relationship is expressed as

$$\log J = \log AT^2 - \psi s / kT + B_{SR} \times E^{1/2}$$

and that log J vs E plot referred to a s Schottky plots should be a straight line with a positive slop for the present case these shown in figure 4. The linear positive slope indicates that Schottky-Richardson mechanism is applicable to the conduction process in PS-PMMAblend film of pure doped with salicylic acid, But not in the case of Poole-Frenkel mechanism.

The temperature dependence of current density is presented in the form of log J vs T plots in fig.5, which shows that log J. log j increases almost linearly with temperature.

The temeperature dependence is in agreement with the Schoottky Richardson mechanism. Further that the slo9pes of all the lines are nearly same for all the fields, shows that no thermodynamic transition occurs in the temperature range studied.

3.4 Arrhenius Plots :

The log 6 vs 1/T plots (Fig.6) at all values of applied voltages show parallel straight line with negative slop9e from the slope is straight line, the activation energy is calculated and found to be in the neighbourhood of 0.1 ev.

This is in good agreement with the reported order of magnitudes.

Conclusion :

The conduction mechanism applicable in the case of PS PMMA pure and doped with salicylic acid blend film is the Schottky-Richardson mechanism. Current density temperature plots indicate the absence of thermodynamic transition in the temperature range studied. The activation energy is is found to agree with the reported order of magnitude.

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