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NOVEL POLYMER NANOCOMPOSITES FOR MICROELECTRONICS APPLICATIONS

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Abstract:
The effect of polarization time on the space charge relaxation behavior of pure and nano ZnO doped PVK samples has been studied. The study has been carried out by thermally stimulated depolarization current patterns of electrets formed by polarization method at 350 volts field strengths at 40◦C to 70◦C with constant heating rates. The results obtained show the shift of the TSD peak position towards lower temperature ranges. Decrease in activation energy was observed corresponding to the increase in polarizing field. The intensity of the peak maxima results in being a good indicator of the trapped carrier number evolution. For high temperatures and high electrical fields the saturation of the phenomenon is achieved faster, which is attributed to facilitated carrier mobility.

Keywords: *Novel; Microelectronics; Nano composites.*

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1. Introduction

The considerable progress has been made both in the theoretical as well as in the experimental aspects of charge storage and charge transport mechanism in insulating polymeric materials. In spite of continuous increasing attention, the mechanisms of charge generation, its storage and transportation within the organic insulating polymer, and the effect of their structure on these processes is still not fully understood. The application of insulating polymers in electrical industry has increased remarkably over the few years and the information on stabilization of hetero or homo charge is of interest for several industrial applications [1-3]. The Thermally Stimulated Current (TSC) technique is ideal for the investigation of the structure of polymers, semi-crystalline polymers and co-polymers because it is a more sensitive alternative than other thermal analysis techniques for detecting the transitions that depend on changes in mobility of molecular scale structural units [4].

1.1. Experimental

The phenomenon of dielectric relaxation is due to the hindrance to the motion of dipoles and tree charges by frictional forces, and inherent inertia of motion. Therefore, on application or removal of an electric field, a polar molecule is neither charged nor discharged immediately. Only that

part of its polarization which originates from electrons or ion displacement within the atoms or molecules respond practically immediately. Since internal friction has been found to be exponentially proportional to the temperature, the response time to an external field is accelerated at elevated temperature and decelerated at comparatively lower temperature. In polymers, the response time changes sharply near the glass rubber transition temperature, T, where the contormational motion of the main chain segments set in. Hence, polymers having their Tg above room temperature can be permanently charged by subjecting them to a field temperature treatment.

Different steps for the preparation of a thermoelectret are as follows (i) the sample is heated to the desired polarizing temperature Tp; it is kept at Tp for some time (in the present case, 1 h) to reach thermal equilibrium;(ii) then,an electric field (Ep) is applied at Tp and kept on for a period of polarizing time (tp); it is then cooled slowly under the field application to room temperature. The field is then removed. The current was recorded with an electro meter (keithley 600 B), which was carefully shielded and grounded to avoid ground loops or extraneous electrical noise, as a function of applied field and temperature. The polarized samples were subsequently short-circuited for an arbitrary time of 10 min., so as to remove any frictional and stray charges present. The short circuit TSCs was then recorded by reheating the samples at a linear rate of 3ºC/min.

The material is heated to a temperature Tp above room temperature Tr for some time till the sample reaches thermal equilibrium due to the motion of permanent dipoles and free charges. Next, at time t0 a dc electric field of sufficient magnitude is applied which causes an alignment of the permanent dipoles and the drift of the free charges to the electrodes.

After sometime (approximately one hour) t, the sample is cooled down to room temperature T, with the electric field still on. This causes immobilization of the main chains of the polymers, freezing in most of the permanent dipoles and charges and the end result is a formation of a thermoelectret. When the electret is removed from between the electrodes, it is found to exhibit an electric field on both the surfaces which had been in touch with the electrodes. In certain polymers of low ohmic conductivity and high Tg, such as Teflon FEP, the charge such stored is retained for many years.

2. Results and Discussion

The thermally stimulated discharge current (TSDC) spectra for pure and ZnO doped polyvinyl carbazole(PVK) samples polarized with poling fields 350 volts at constant temperatures 40, 50, 60 and 70°C are illustrated in Figures 1 and 2.

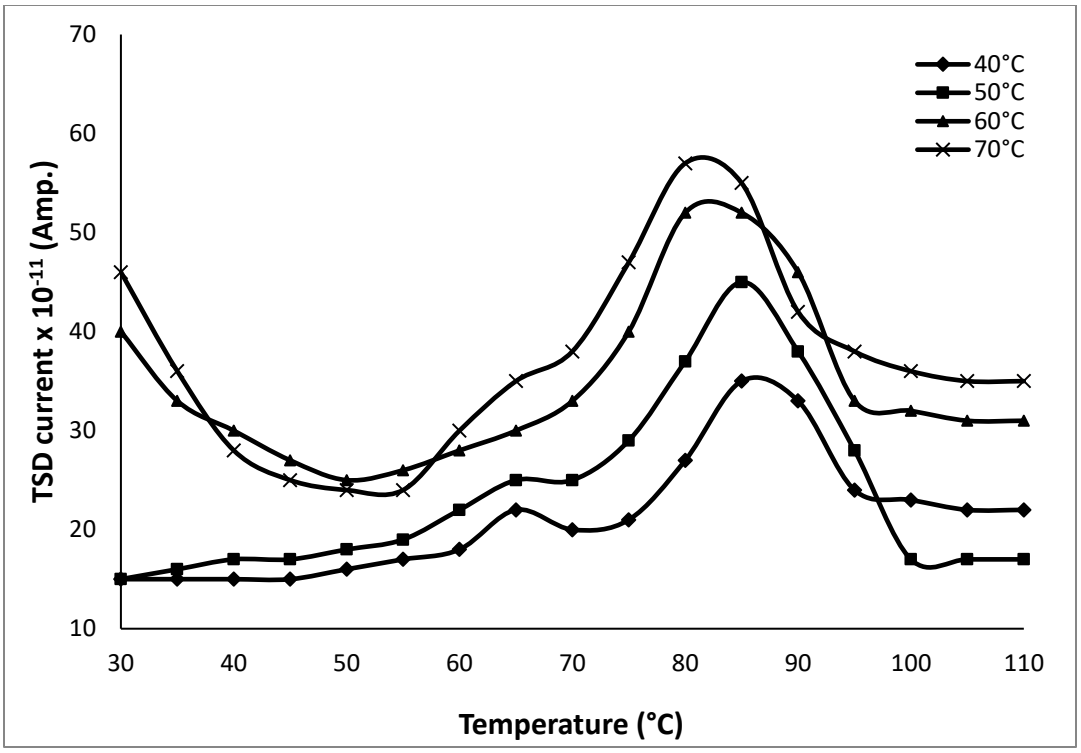

Figure 1: TSDC thermograms of pure PVK samples poled with 350 volts at different polarizing temperatures (i.e. 40, 50, 60 and 70°C)

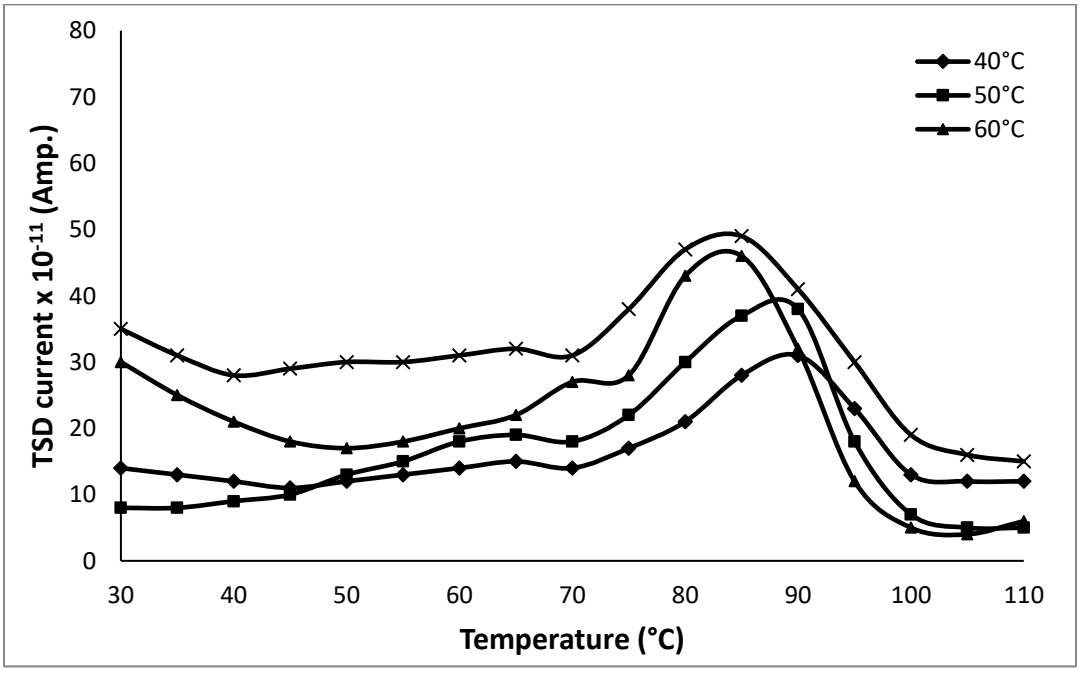

Figure 2: TSDC thermograms of ZnO doped PVK samples poled with 350 volts at different polarizing temperatures (i.e. 40, 50, 60 and 70°c)

In the present case, the appearance of peak in the high temperature region imply that the injection of ions may be significant in this polymer. It is also possible that PVK contains a high

number of impurity molecules prior to field treatment and these molecules are dissociated into various ionic species by a combination of the high internal and external fields[5]. The charge trapping in a polymer takes place at the molecular main chain, the side chain and at the interface of crystalline and amorphous regions of the polymer. The high field applied during elected formation may also produce some additional trapping sites[6-10]. This can easily be explained from the fact that relaxation phenomenon is due to the internal friction of the polymer which depends exponentially on temperature. The time lag corresponding to the motions of permanent dipoles (ions, free and trapped charges) changes markedly with temperature.

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