



RELAXATION INVESTIGATIONS AND THERMALLY STIMULATED POLARIZATION CURRENT (TSPC) STUDY IN PURE AND DOPED PVK SAMPLES

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Abstract

The temperature and electric field dependence of dielectric relaxation have been investigated in pure and malachite green doped PVK samples. Thermally stimulated polarization current of polyvinyl carbazole (PVK) thermoelectrets prepared at the forming temperature $T_p=70^{\circ}\text{C}$ and polarizing field 20 KV/cm. One sharp peak appears at around 90°C . The peak obtained at lower temperature (i.e. β -peak) is associated with dipolar relaxation. Doping with malachite green is found to affect the magnitude and decrease in activation energy. The effect of malachite green is explained in terms of the formation of charge transfer complex.

Keywords: TSDC, space charge, activation energy, relaxation time

Introduction

During the last three decades, development in the field of electrets have continuously extended the fascinating world of micromechanics [1-5]. In early days, polymers in the form of plastics were regarded electrically as simply good insulators. But now, observations as substitutes in electrical response have shed a great deal of light on their molecular and charge particle dynamics. Such studies have enabled the development of materials which meet exacting electrical engineering requirements. Research along these lines has demonstrated the feasibility of obtaining materials with entirely novel set of properties. Also, such a research has led to the discovery of 'electret' displaying an unusual electrostatic phenomenon. Electrets made of

different polymers have a very important use as transducers in electret microphones. Subsequent researches led to permanent electrification of electrets. Such electrets are utilised in xerographic reproduction techniques gas filters, relay switches medical appliances like radiation dosimeters, optoelectronic devices like video/TV cameras, maritime devices like hydrophones, electret motors, electret generators, tachometers, vibrational fans thin film transistors and thin film memory circuits and many other areas[6-8]. Even nature takes advantage of thin-film approaches: for example, seashells are built up of inorganic and organic components through a complex deposition chemistry. This deposition can be reproduced by a low-temperature biomimetic process in which directed nucleation and growth of inorganic layers on self-assembled organic templates produce continuous films of single-phase ceramics [9].

Experimental

For preparing the thermoelectrets, the polymer sample was kept inside the sample holder housed in a thermostat. The upper electrode of the sample holder was connected to a high voltage power supply giving the desired voltage as calculated above. The sample was heated to the desired temperature and kept for 30 mins. to attain thermal equilibrium. The power supply unit was then switched on and the positive polarising field was applied to the sample for 45 mins. Thereafter, the sample was cooled to the room temperature with the field still ON. The field was then switched OFF and the electret was short circuited for an arbitrary time of five mins.

to remove any frictional or stray surface charges. For measuring the TSDC, the sample was discharged by heating at the linear rate of $3^{\circ}\text{C}/\text{min}$. upto 150°C to achieve complete depolarization. The current was measured by Keithley electrometer[10].

RESULTS AND DISCUSSION

The experimental conditions under which the thermally stimulated discharge currents were measured are summarized below –

Polarizing field strength -200, 300,400,500 volts

Polarizing temperature -30°C , 40°C , 50°C and 60°C

Heating Rate- $3^{\circ}\text{C}/\text{min}$.

Electrode Material - Aluminium

The thermally stimulated discharge current (TSDC) spectra for polyvinyl carbazole (PVK) samples polarized with poling fields 200, 300, 400 and 500 volts at constant temperatures 30°C , 40°C , 50°C and 60°C are illustrated in Figures 1 – 4.

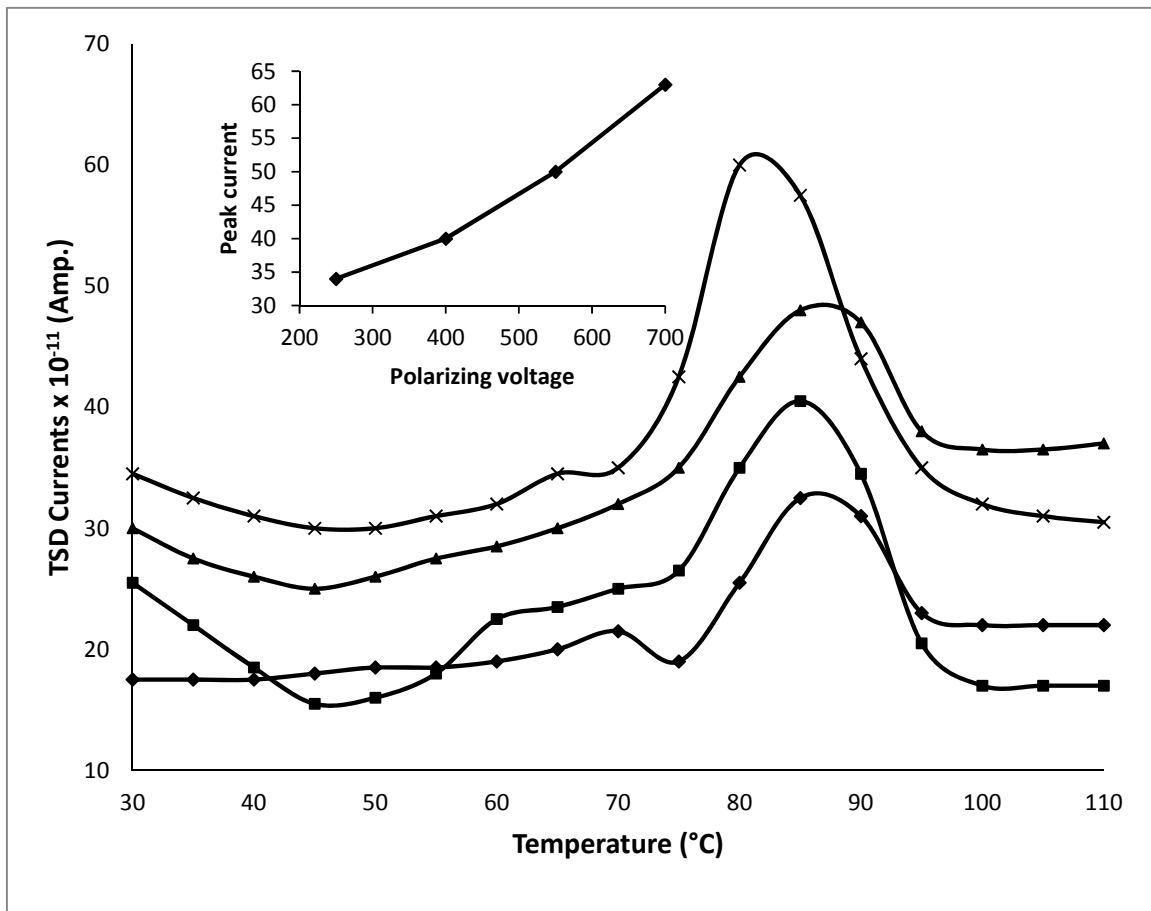


Figure 1: TSDC thermogram of pure PVK samples poled at 30°C with different polarizing fields (i.e. 200, 300, 400 and 500 volts).

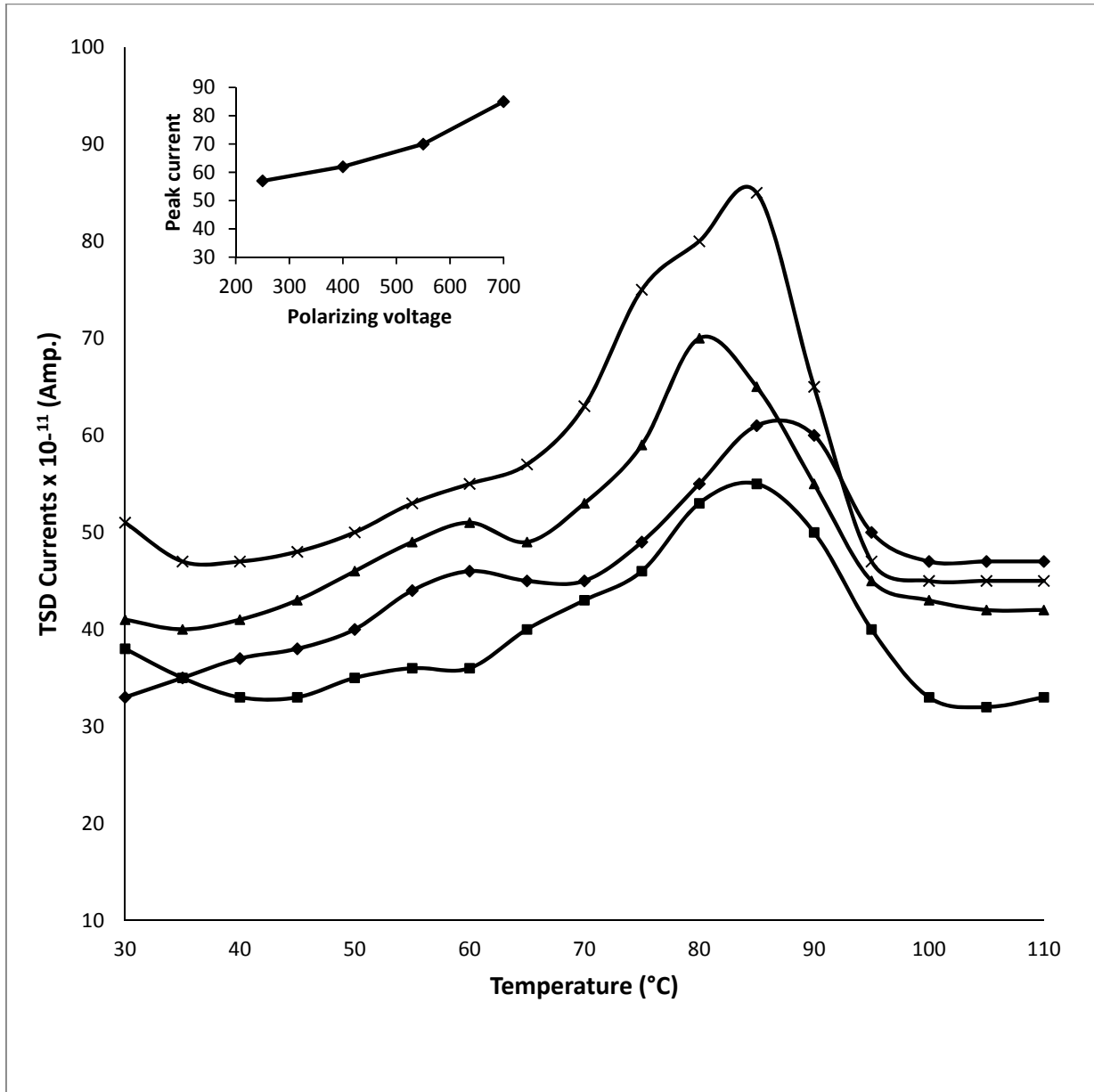


Figure 2: TSDC thermogram of pure PVK samples poled at 40° C with different polarizing fields (i.e. 200, 300, 400 and 500 volts).

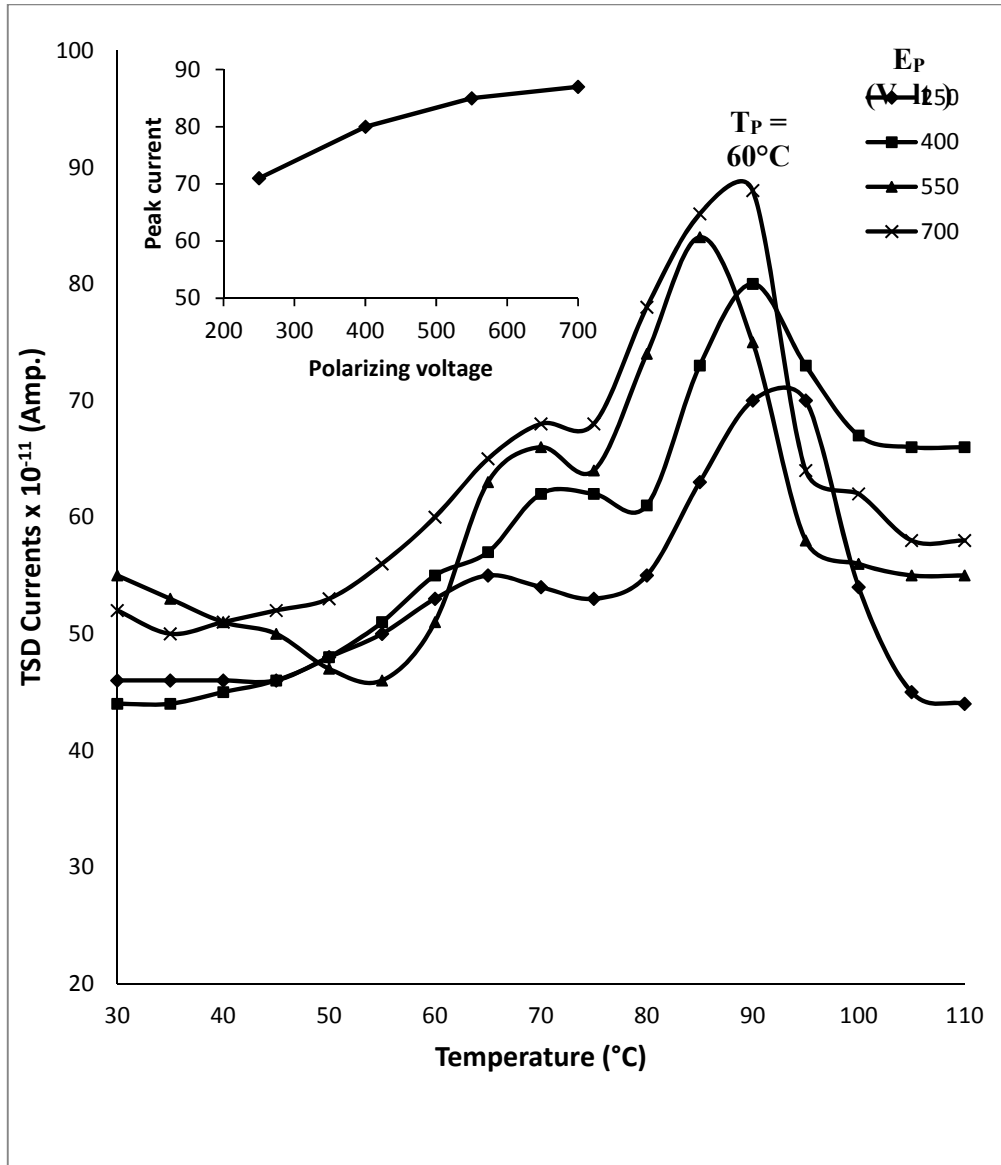


Figure 3: TSDC thermogram of pure PVK samples poled at 50°C with different polarizing fields (i.e. 200, 300, 400 and 500 volts).

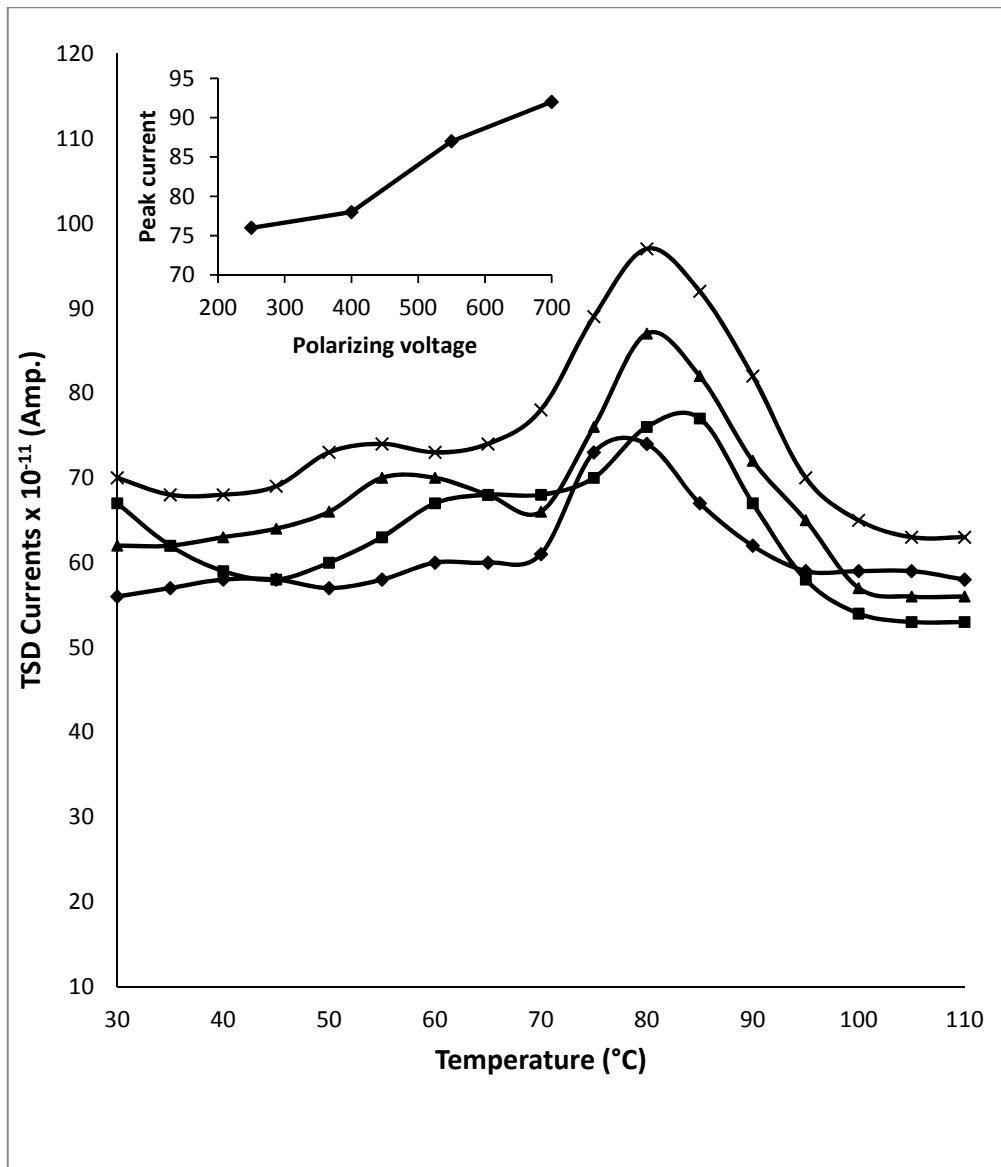


Figure 4: TSDC thermogram of pure PVK samples poled at 60°C with different polarizing fields (i.e. 200, 300, 400 and 500 volts).

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. 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 [11-14]. The high field applied during elected formation may also produce some additional trapping sites.

The charge released from these traps occurs because of the thermal excitation and motion of the molecular chain that causes the lowering of trap depth. The released charge can recombine, retrapped in trapping sites, or may get discharged at the electrodes. The chances of retrapping of the released charge are high in a polymer having a large number of trapping sites and it is expected that the discharge will give complex TSC spectra with broad peaks indicating a distribution of activation energies.

The results can be explained on the basis of formation of charge transfer complexes between dopants and polymer matrix. Swan [15]

proposed four mechanisms for the charge transfer complex processes involved between the strong electronegative acceptors present in the polymer molecular chain.

- (i) The electron may go back to the polymer molecule from which it originates.
- (ii) The electron may be retained by the dopant and may move as a stable negative ion.
- (iii) The electron may transfer from the negative dopant into another polymer molecule without motion of the dopant molecule and
- (iv) A charge exchange may occur between the negative dopant ion and a neutral dopant molecule.

The formation of CTC will result in the reduction of the crystalline amorphous interface and provide conducting paths through the amorphous regions and thus interconnect the crystallites. Due to the reduced barrier at the interfaces the mobility of the dipoles and/or charge carriers will increase[16].

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