Isolation of Spontaneous Current Emission During Thermally Stimulated Depolarization Current Studies in Hygroscopic Materials

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Hygroscopic polymeric materials can be studied for the practical applicability using Thermally Stimulated Depolarization currents. Experimentaly measured currents are viciated by the spontaneous current emission. Dependance of the spontaneous current emission on the difference in the work functions of the metals used as electrodes is used to eliminate its interference. A graphical subtraction method developed has been presented using Acacia gum as an example.

When celluiosic materials [1], polysaccanides [2] and other polymers (3) are heated between two metal electrodes, a short circuit current is generated. The magnitude and the direction of this current entirely depends on the difference in the work function of the chosen electrodes and it is reproducible on repeated heatings. The origin and the nature of this current is reported to be dependent on the electrochemcal reaction at the electrode specimen interface. The phenomenon of generation of this current is known as spontaneous current emission. A solid polymer when subjected to simultaneous action of heat and a steady state electric field, exhibits a current which is similar to spontaneous current emission but the current is not reproduced on repeated heatings.

To study about internal polarization in a polymer, the technique of thermally stimulated depolarization is useful. Here the current in external circuit is observed as a function of temperature during heating a polarized sample. Hygroscopic polymers have been found to exhibit large spontaneous current emission. This current is to be eliminated during thermal stimulation studies.

During thermally stimulated depolarization studies of some of the polyelectrolytes[5] graphical subtraction procedure was developed to eliminate spontaneous current emission from the measured current.

Therory

Thermally stimulated depolarization current results from depolarization of polarized state in dielectrics. Let this current be called $I_{(dp)}$. Spontaneous current emission results from simple heating of an unpolarized sample. Let this be called $I_{(sp)}$. The measured current is the sum of the two. This calls for a necessity to eliminate $I_{(sp)}$ from the total current $I_{(sp)} + I_{(dp)}$.

Spontaneous current emission in polysaccharides[2,4] shows magnitude and direction of $I_{(sp)}$ to be dependent on the combination of electrode materials. Let two electrodes employed for TSD studies be designated as A and B. Let us suppose that during polarization, the positive terminal of power supply is connected to A, then the current flowing through the electrometer during polarization will be positive. During depolarization in short circuit, A is directly connected to earth and B is connected to the electrometer. This is the usual circuit connection for polarization and depolarization. Under this condition,the depolarization current is always negative. Thus the magnitude and even direction of the total current $I_{(dp)} + I$ may vary from experiment to experiment. So one should choose a pair of electrodes of different work functions so that the magnitude and direction of $I_{(sp)}$is certain, then the separation of $I_{(sp)}$becomes easier. It has been observed that the magnitude of $I_{(sp)}$ is less if the difference in work functions of the electrodes is small[6]. Thus a pair of electrode of different kinds of materials and having a small difference in thier work functions is recommended. In our case of polyelectrolytes[5] A and B were chosen to be copper and aluminium respectively. This combination gave $I_{(sp)}$ always negative. The value of $I_{(sp)}$ is determined using a fresh sample and correction applied to the measured current in the thermally stimulated depolarization study.

Procedure

The method of isolation of actual depolarization current with Cu and Al as electrodes has been shown in Fig. 1 in case of Acacia gum samples polarized at 2, 5 & 10 KV/cm at 75°C. Curves 'A' represent thermally stimulated depolarization current i.e. $I_{(dp)} + I_{(sp)}$ from a polarized sample. Curve C represents short circuit current $I_{(sp)}$ from an unpolarized sample which has been given the

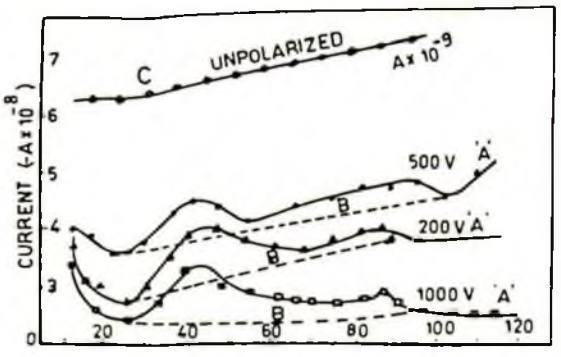


Fig. 1 Plot between depolarization current versus temperature in the case of Acacia

same heating and cooling treatment before noting $I_{(dp)}$ of the polarized sample. This treatment is necessary because $I_{(sp)}$ from a vergin sample differs from that due to the sample which has been given a heat and cool treatment [1,6]. Keeping the magnitude (at different temperatures) and shape of $I_{(sp)}$ i.e. curve C in mind, imaginary curves marked B, (dashed curves in Fig.1) are drawn to match with the end part of A. Curve B, so drawn, is then supposed to be the spontaneous current component from the sample for which the curve A has been obtained. The actual depolarization current will then be given by a curve obtained by graphical substraction of curve B from curve A. Thus the peak value of the depolarization current for a particular field will be the difference between the peak value of curve 'A' for the field and the value of current in the corresponding curve 'B' at the temperature where the peak in curve 'A' is observed. The total charge released from the thermoelectret will be equal to the area bounded by curve 'A' and B.

ACKNOWLEDGEMENT

Author expresses thanks to Dr. A.P. Srivastav Professor and head, Physics department. Dr.H.S.Gour Vishwavidyalaya, Sagar, for encouragement.

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