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NOTE

Temperature Dependence of Dielectric Constant on Pure Polymethyl Methacrylate

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Temperature variation is investigated for the dielectric constant of polar polymer, pure polymethyl methacrylate (PMMA). Measurements were carried out in the temperature range 35–80°C at various applied a.c. frequencies. The obtained results indicate that the dielectric constant and dielectric loss increases with increase in temperature due to enhancement of the polarization.

It is now well established that the application of electric field on the polymers gives rise to polarization, which results into modification of various electric properties of the polymers, like dielectric constant and dielectric loss, etc. These dielectric properties play an important role in the conduction behavior of these polymers[1] and can easily be measured by dielectric A.C. bridge measurements technique, in which dielectric properties are monitored as a function of temperature and frequency. The technique has already proved itself a most convenient, sensitive and versatile method to study the polymeric structures[2, 3].

In order to understand the applications of the polymeric materials, emphasis has been given to study the dielectric characteristics of the polar and nonpolar polymers, in the recent years[4–6]. Keeping this in view, it is considered worthwhile to carry out a detailed investigation on the effect of temperature on dielectric constant of a polar polymer, polymethyl methacrylate.

The polymer polymethyl methacrylate (PMMA) was obtained from IPCL, Baroda (India) in the form of film sheet. The film of the polymer was made by solution cast technique[7] and to remove the traces of the solvent, it was properly dried in an air oven for about 24 h. The working samples were prepared by cutting square portions of area 15 mm × 15 mm each from the dried film and by applying silver paste (no. 1228), obtained from Elteck Corporation, Bangalore (India), on both the faces of the square samples. The dielectric constant measurements were carried out by pressing the working sample between two metal electrodes of Hewlett Packard Impedance Analyzer (4192 ALF). All the measurements were made over the frequency range 400 Hz to 100 kHz and temperature range 35–80°C.

The variation in dielectric constant with temperature at different applied a.c.

frequencies for the pure PMMA samples is presented in Fig. 1. The graph clearly indicates that the dielectric constant increases with increasing temperature in the entire frequency range. As PMMA is a polar polymer, hence increase in dielectric constant verifies the fact that with the rise in temperature, enhancement of polarization of the material is taking place. This behaviour also shows that at lower temperature, when the dipoles are almost frozen, they find themselves unable to orient in the direction of the applied field. However, with the increase in temperature, facilitation of molecular motion of the chain segments takes place, which thereby allows the orientation of dipolar units, as a result of which polarization increases.

The graph also exhibits that for pure PMMA, with increase in applied a.c. frequency the values of the dielectric constants decrease. This behaviour further indicates that with the rise in the magnitude of applied a.c. frequency, it becomes difficult for the dipoles, present in the PMMA, to keep pace with the fast changing a.c. field and a continuous drop in the value of dielectric constant is observed.

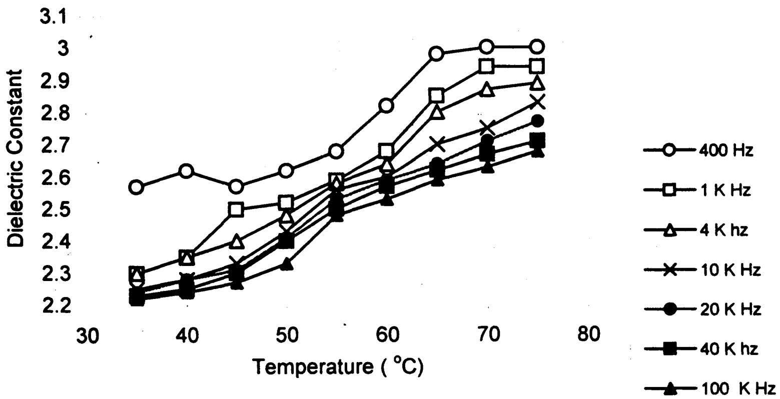

Fig. 1 The dependence of temperature on dielectric contant of PMMA

The decrease in dielectric constant with increase in frequency can also be attributed to the space charge polarization or interfacial polarization arising due to heterogeneity of the electrical properties of polar polymers[8, 9]. In the presence of the electrical field the charges, present in the form of electrons or ions, may tend to pile up at the crystalline-amorphous boundaries Hence, at lower frequencies, it is possible for the space charge formation to be in phase with the variation of the a.c. field; however, it is not possible at higher frequencies.

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REFERENCES

1. J. Van Turnhout, Thermally Stimulated Discharge of Polymer Electrets, Elesevier, Amsterdam (1975).
2. H. Frensch and J.H. Wedroff, *Polym.*, **27**, 332 (1986).
3. Vineeta Jain, Alok Mittal, N. Chand, S.A.R. Hashmi and J.M. Keller, *J. Mater. Sci. Letters*, **19**, 531 (2000).
4. S. Radhakrishnan and D.R. Soni. *J. Polym. Eng. Sci.*, **33**, 125 (1993).
5. G.K. Narula and P.K.C. Pillai, *J. Mater. Sci. Letters*, **8**, 608 (1989).
6. R. Dabek, *J. Polym. Eng. Sci.*, **36**, 1065 (1996).
7. Vineeta Jain and Alok Mittal, *J. Mater. Sci. Letters,* **19**, 1991 (2000).
8. G.K. Narula, Rashmi and P.K.C. Pillai, *J. Macromole. Sci. Phy.*, **B26**, 25 (1987).
9. P.T.A Klasse and J. Van Turnhout, *IEEE Publication*, **177**, 411 (1979).

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