

Synthesis and electrical behaviour of poly(chlorotrifluoroethylene)

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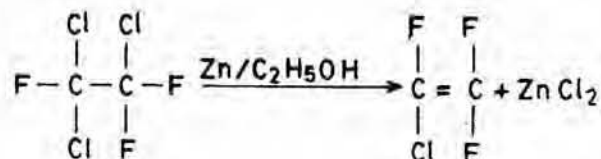
The synthesis of poly (chlorotrifluoroethylene) [PCTFE] and its electrical measurements are reported here. A linear increase in current with voltage up to 400 V, and an exponential increase thereafter, is observed at all the studied temperatures. This is an indication of the Schottky or Poole Frankel conduction mechanisms to be operative. The variation of dielectric constant and dielectric loss with frequency at the studied temperatures suggests the contribution of electronic and ionic polarization to this effect.

Polymeric materials are unique because of the range of structural forms they can be synthesized and the way in which changes can be made in their structure. Structural order is very important to conductivity mechanisms. Polymers can exist as amorphous, crystalline, or mixtures of crystalline and amorphous materials. In contrast to many other materials, polymers do not have a unique molecular weight. Despite the steady increase in applications of synthetic organic polymers as electrical insulating materials, a lot of work on their electrical conduction is being carried out.

The fluoropolymers due to their high thermal stability and chemical inertness have found widespread applications in the fields of electrical, mechanical, environmental and space engineering as well as in medicine and material sciences¹. The low surface energy of fluoropolymers² prevents the formation of strong bonds. Hence, these are not softened or wetted by most solvents making them suitable for applications in any corrosive environment.

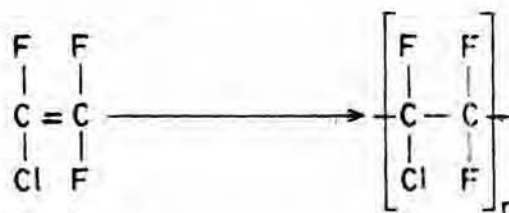
The monomer of poly(chlorotrifluoroethylene) was synthesized by the dechlorination of 1,1,2-trichlorotrifluoroethane (Freon 113) with zinc/ethanol system using zinc chloride as catalyst. Soluble impurities were removed by scrubbing with deionized water.

Note



Then, it was dried by scrubbing with sulphuric acid, potassium hydroxide pellets, phosphorous pentoxide and anhydrous calcium chloride.

The monomer was then polymerized under vacuum in a stainless steel vessel. Distilled water (300 g) was added to the reaction vessel followed by the addition of 2.66 g/50 mL each of potassium persulphate, potassium salt of penta decafluoro octanoic acid and disodium hydrogen phosphate. Finally, 100 g of CTFE was transferred to the reaction vessel and kept at liquid nitrogen temperature. The temperature of the vessel was then slowly raised to 70 °C and maintained at that level for 12 h. PCTFE was separated from the emulsion by the addition of magnesium chloride at 80 °C. The polymer was then washed with hot/cold water and dried at 35 °C in a vacuum oven.



PCTFE was characterized by IR spectroscopy and elemental analysis. Besides other IR peaks, a very strong peak at 969 cm⁻¹ indicated C-Cl stretching. No unsaturation peak at 1794 cm⁻¹ was detected in PCTFE. The results of elemental analysis for carbon (20.14%) and chlorine (30.47%) were in good agreement with the theoretically calculated values. The thermal analysis studies showed that the polymer is thermally stable up to 350 °C.

Both dc and ac measurements have been made on PCTFE. Fig. 1 shows the variation of current with volt-

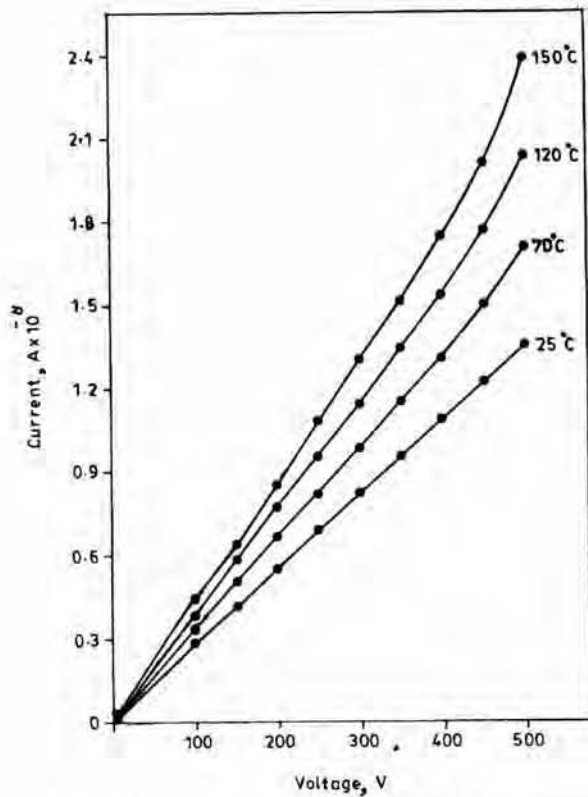


Fig. 1—Current-voltage characteristics of PCTFE at different temperatures

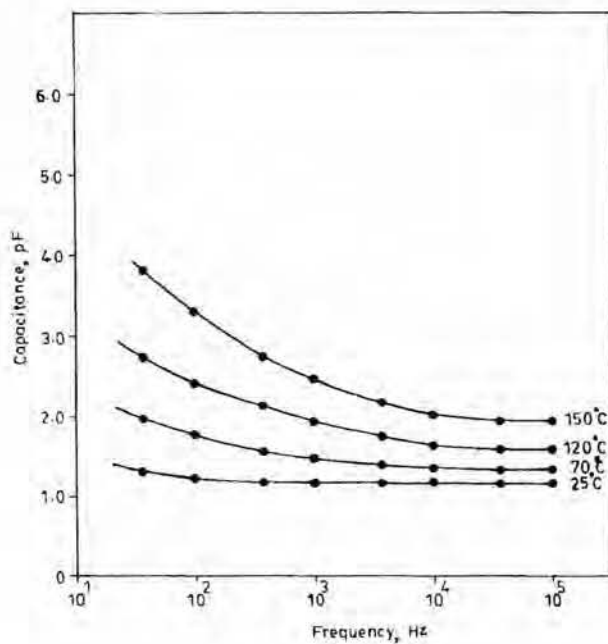


Fig. 2—Variation in capacitance as a function of frequency at different temperatures

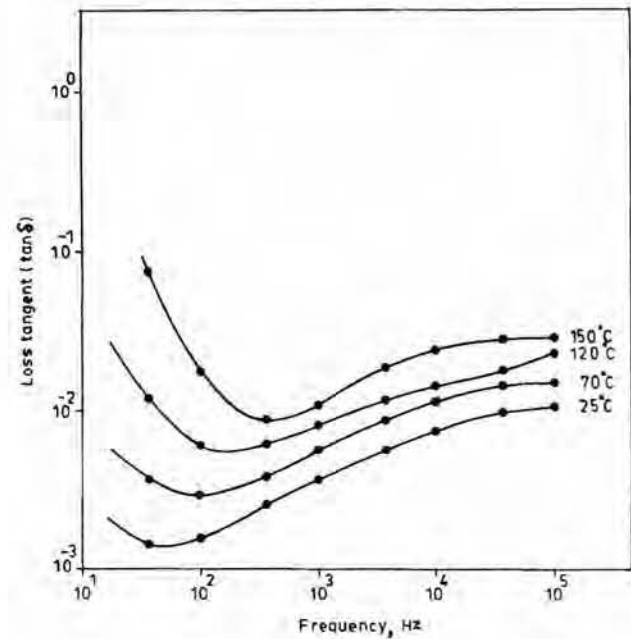


Fig. 3—Variation in loss tangent ($\tan \delta$) as a function of frequency at different temperatures

age at different temperatures. Up to 400 V, there is a linear increase in current with voltage at all the studied temperatures. Further increase in voltage gives an exponential increase in current values. However, as the temperature decreases, the increase in current with voltage slows down. Such behaviour is usually associated with either Schottky or Poole-Frenkel conduction mechanisms^{3,4}.

The ac behaviour of PCTFE was studied in the frequency range 0.10-100 KHz. Fig. 2 shows variation in capacitance with frequency. Initially, capacitance decreases slowly with frequency and then tends to be independent at higher frequencies. The influence of frequency and temperature on loss tangent ($\tan \delta$) is illustrated in Fig. 3. $\tan \delta$ decreases with frequency, attains a minimum at relatively higher frequencies for higher temperatures, and then increases slowly. Such behaviour has been reported for many other dielectric materials⁵⁻⁷.

The increase in both capacitance and $\tan \delta$ towards the low frequency region may be attributed to interfacial polarization. The resulting space charge region leads to a substantial increase in capacitance towards low frequencies⁸. Similar observations have been made by other workers^{9,10}. On the other hand, no clear relaxation effect (i.e. $\tan \delta_{\max}$) is observed in the studied frequency and

temperature ranges. The contribution from orientational polarization and possibly from interfacial polarization can be ruled out. Thus, the electronic and ionic polarization is suggested to be the contributor.

Acknowledgement

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