C-11

Correlation Between Electrical and Mechanical Breakdown in Chain-Polymer Solids

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Studying the electric breakdown of high-polymer solids used as insulating materials, the author found that the variations in d.c.(i.e. direct current) dielectric strength (i.e. electric breakdown voltage per unit thickness of material) with temperature resemble the variations in tensile strength with temperature of chain-polymer solids[2].

Between the tensile strength and the dielectric strength the following relation was obtained :

$$P = aE \exp(bE) \qquad \text{------------ (1)}$$

where P is the tensile strength, E the dielectric strength, a and b constants depending only on the units of P and E. This relation holds good for any chain-polymer solids irrespective of their kinds and observed temperatures. Taking kg/cm^2 for P and 10^6 volt/cm for E, we have $a \doteqdot 7.7$ and $b \doteqdot 1/3$, then Equation (1) becomes :

$$P \doteqdot 7.7E \exp(E/3) \qquad \text{----------- (2)}$$

The observed tensile strengths (P) of several chain-polymers are compared in Fig.1 with the values calculated by the author's Equation (2) using the observed values for E. The solid lines in Fig.1 show the variations in tensile strength (P) with temperature, and the broken lines show its calculated values. P.E., P.S., P.C., P.T.F.E. and P.T.F.C.E. are abbreviations for polyethylene, polystyrene, polycarbonate, polytetrafluoroethylene and polytrifluorochloroethylene respectively. The curve of the Equation (2) is given in Fig.2 as the solid line, and its measured values are plotted near this curve. The observers of the data quoted above are as follows. The dielectric strengths of P.E. and P.S. were obtained by Oakes[3], and of P.C., P.T.F.E. and P.T.F.C.E. by the author. The tensile strengths of P.T.F.E., P.T.F.C.E., P.E. and P.S. were obtained by Doban et al.[4], and of P.C. by Hechelhammer et al.[5]

Naturally the observed values somewhat deviate from the calculated values because for one thing the values of P and E were not

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1. Professor of Instrumentation, Kobe University, Japan.
2. M.Toyoda, Paper presented at Joint Meeting of Four Institutes Relating to Elec. Eng., Pt.1, no.59, April (1961)
3. W.G.Oakes, Proc. Institute Elec. Eng., 96, Pt.1, 37 (1949)
4. R.C.Doban et al., Soc. Plastic Eng. Journal, 11,17,Nov.(1955)
5. W.Hechelhammer et al., Kunststoffe, 49, 8 (1959)

observed by one man, and it may safely be said that these figures show that the above-given correlation apparently exists. Thus, the author considers that the d.c. electric breakdown of chain-polymer solids results primarily from the mechanical stress created by the electric field.

Recently, high-loading-rate tensile properties of chain-polymer solids have been actively studied, but it is not easy to observe very-high-speed mechanical breakdown. Electric breakdown, on the other hand, which occurs as rapidly as in about 10^{-7} sec can be easily observed; then applying Equation (2) to the observed electrical data, super-high-loading-rate tensile properties of chain-polymer solids may be deduced.

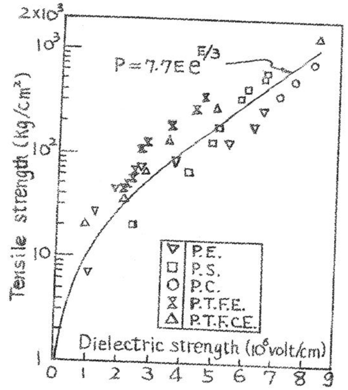

Figure 2 Correlation Between Electrical and Mechanical Breakdown in Chain Polymer Solids.

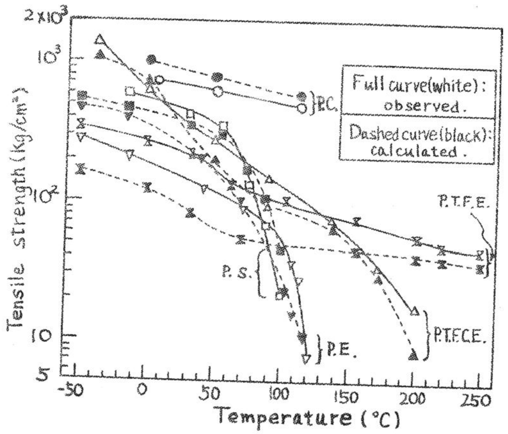

Figure 1 Correlation Between Electrical and Mechanical Breakdown in Chain Polymer Solids.