*Some Observations on Glass Transition of Poly(ethylene Terephthalate) Filaments in the Necking Region**

Drawing of filaments is a process of aligning the molecular chains and is carried out to increase their load bearing efficiency. It involves a "necking" region which is characterized by an abrupt reduction in the cross-sectional area of the filament being drawn. A large number of load-elongation diagrams of undrawn PET filaments were examined, and it was found that the necking took place invariably at ca. 4% extension. Therefore, in the present work we have examined the load required for 3% and 4% extensions in undrawn PET filaments having different degrees of preorientation over a range of temperatures.

Poly(ethylene terephthalate) filaments spun in commercial production plant of J.K. Synthetics Ltd. (India) (Table I) were used. The filaments were drawn to 3% and 4% extensions at 30–110°C using an Instron Tensile Tester with the temperature-cabinet attachment. The samples were kept in the cabinet for 2 min so as to reach the required temperature before they were drawn. The load exerted by a sample at constant extension at different temperatures was recorded. The loads for sample B and sample C were normalized on the basis of the denier of sample A. The typical relationship between the load at constant extension of 4% and temperature is shown in Figure 1. It is seen from Figure 1 that the load increases in the order sample A < sample B < sample C, that is, in the order of increasing takeup speeds. At high takeup speeds, during melt spinning of filaments, the increase in the elongation rate in the molten region of the threadline induces a higher degree of orientation in the filament[1] and, in turn, more force to elongate during drawing.[2] The effect of temperature on filaments with different preorientation is also different. At a given temperature, a sample with higher preorientation has higher shrinkage,[3] may exhibit higher relaxation tension on heating under taut condition, and, in turn, higher load at a constant extension. There is an abrupt drop in load for all samples at both 3% and 4% extensions as the drawing temperature approaches the glass transition temperature of polyester. As the temperature increases above T_g, the behavior of samples show less difference, and the load at a constant extension for three samples is almost same. Thus, when the molecular chains are free to move and reorganize themselves above T_g, the degree of orientation in the filament loses its significance and does not contribute to the load required to extend the filament.

The rate of drop in load at a particular temperature (i.e., the mean of two adjacent temperatures of measurement) was calculated for every 5° rise in temperature and is shown in Figures 2 and 3 for 3% and 4% extensions, respectively. The rate of drop in load is small up to 75°C, after which it exhibits an abrupt change, for all the three samples and for both 3% and 4% extensions. The transition around 75°C is sharper for 4% extension than for 3%

TABLE I
As-Spun PET Filament Samples

Sample	Takeup speed (m/min)	As-spun denier	No. of filaments
A	1000	253	34
B	2500	277	34
C	3000	244	34

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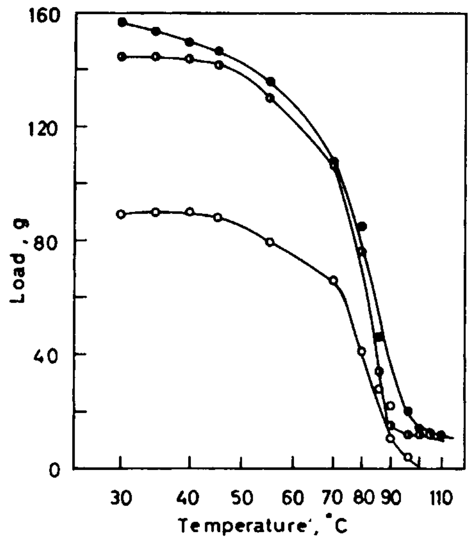

Fig. 1. Relationship between load-at-4% extension and temperature (in log scale): (○) sample A; (◑) sample B; (●) sample C.

extension (Figs. 2 and 3). Similarly, for samples B and C it is higher than that for sample A, because of their higher preorientation.

In conclusion, the glass transition in PET filaments is sharper near the necking region (4% extension) than prior to necking (3% extension) or when the preorientation is higher. However, the glass transition temperature remains the same for all the samples.

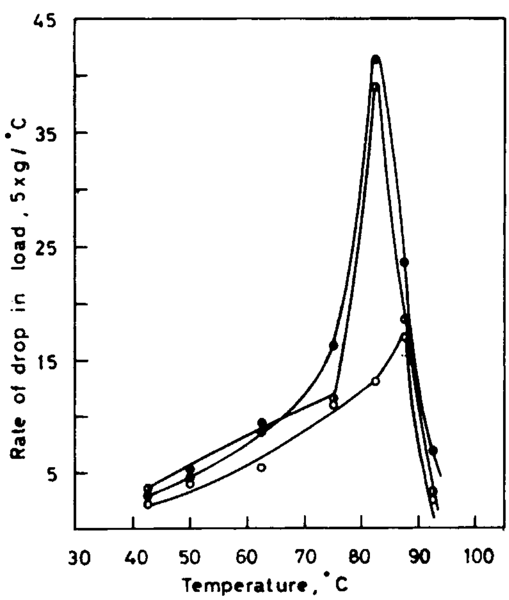

Fig. 2. Relationship between rate of drop in load-at-3% extension and temperature: (○) sample A; (◑) sample B; (●) sample C.

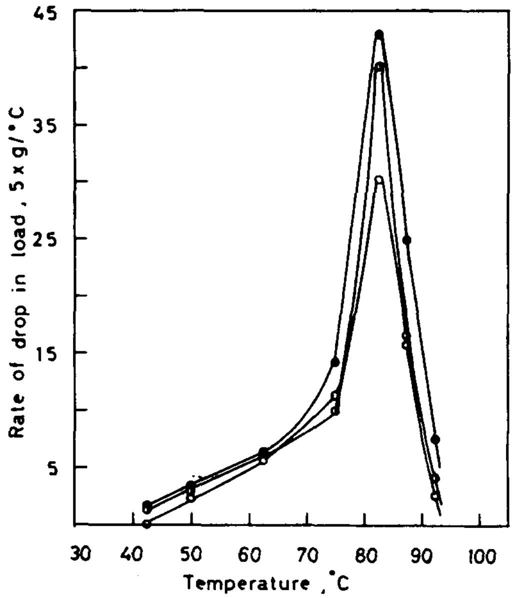

Fig. 3. Relationship between rate of drop in load-at-4% extension and temperature: (○) sample A; (◑) sample B; (●) sample C.

References

1. K. Nakamura et al., *J. Appl. Polym. Sci.*, **16**, 1077 (1972).
2. A. Hamidi, A. S. Abhiraman, and P. Asher, *J. Appl. Polym. Sci.*, **28**, 567 (1983).
3. W. Roth and R. Schroth, *Faserforsch Textiltech.* **11**, 365 (1960).

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