Sticking Behavior of Preoriented PET Yarns

We have had occasion to examine the physical properties of a number of largely amorphous poly(ethylene terephthalate) (PET) homopolymer yarns and single filaments, i.e., the product of the primary melt-spinning process. If such yarns are essentially unoriented, as indicated by an optical birefringence of less than 0.010, for example, and by other properties, then the differential scanning calorimetry (DSC) curve is the typical one,[1] showing the glass transition at 70°–75°C, a substantial crystallization exotherm centered at about 130°C, and the final melting near 258°C. If, however, the yarn has a substantial degree of orientation (birefringence of 0.04, say) but is still largely amorphous, i.e., it has been preoriented during the spinning process, then the crystallization exotherm is shifted downward in temperature by substantial amounts, in our experience by as much as 40°C. The preoriented fiber thus begins and continues to crystallize at lower temperatures than does unoriented yarn.

This shifting of the crystallization tendency by preorientation has important consequences with respect to the further processing, handling, and sticking characteristics of the yarn. Once the amorphous polymer is heated beyond the glass temperature, as in drawing, its viscosity decreases rapidly and would reach very low values were it not for the intervention of crystallization, which increases markedly the viscosity of the solid. The sticking tendency of one filament to the next or to a solid surface, which must be closely related to the viscosity–temperature behavior, becomes less and less as the temperature of the onset of crystallization becomes closer to the glass transition.

TABLE I
Crystallization Exotherm Position
and Zero Strength Temperature of Various P.E.T. Yarns

Yarn	Birefringence	Crystallization exotherm centered at	Temp. of zero strength
A	0.004	138°C	145°C
B	0.003	135	145
C	0.010	131	143
D	0.008	131	145
E	0.038	107	250
F	0.050	106	240
G	0.056	97	234
H	0.055	98	232
I	0.218	—	251

Given in Table I are some values of the central position of the crystallization exotherm, as observed with a properly calibrated Perkin-Elmer DSC-1B instrument at a 20°C/min heating rate, and corresponding "zero strength" temperature measurements. These latter, admittedly somewhat arbitary, were determined on a metal temperature gradient bar by noting the temperature at which yarn bundles broke under a very small stress. Fresh specimens were used for each temperature exposure. Yarn I, unlike the others, was an already drawn, substantially crystalline fiber showing no detectable DSC crystallization exotherm; at 20°C/min, it showed a melting endotherm centered at 255°C. All of the other fibers showed melting endotherms centered between 250° and 255°C.

References

1. J. L. Koenig and M. D. Mele (p. 83) and E. L. Lawton and D. M. Cates (p. 89), in *Analytical Calorimetry*, R. S. Porter and J. F. Johnson, Eds., Plenum Press, New York, 1968, pp. 83 and 89.

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Received June 9, 1972
Revised July 5, 1972