Crystalline Structure and Mechanical Properties of Oriented ODPA-DMB Polyimide

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The 4,4'-oxydiphthalic anhydride (ODPA)-2,2'-dimethyl-4,4'-diaminobiphenyl (DMB) polyimide fibers, which were spun with a dry-jet spinning method in phenol, were drawn at various draw ratios (DR) by a zone drawing method. The ODPA-DMB polymer solution in phenol was also cast into film and later drawn in one direction.

X-ray fiber diagrams were used to determine the crystallographic unit cell of ODPA-DMB polyimide in highly drawn films and fibers. It was determined to be triclinic with a=1.050nm, b=0.8712nm, c=2.141nm, α=45.6°, β=53.7°, and γ=61.4°. The length of c-axis was almost the same as the molecular repeating unit length, 2.13nm. The unit cell crystallographic density for perfect crystalline ODPA-DMB was 1.4420g/cm^3.

The relationship between density and X-ray crystallinity which was determined by powder patterns was established. The density of perfect amorphous was found to be 1.2927g/cm^3 from the extrapolation to zero degree of crystallinity.

The overall orientation, crystal orientation, and amorphous orientation of the drawn films were analyzed by optical birefringence and crystal orientation factor. The crystallinity and crystal orientation increased with DR but the increasing tendency slightly decreased at DR of 3.4.

The mechanical properties of the fibers were determined by Rheometrics Solid Analyzer. The tensile strength was 123MPa with a strain of 13% for as-spun fiber, which changed to 510MPa with 3.3% strain for fibers with DR of 2.9. The initial modulus increased with drawing from 3.7GPa (as-spun) to 25.7 GPa (DR of 2.9).