

High Speed Melt Spinning of Nylon 6 / PET Bicomponent Fibers

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1. INTRODUCTION

The bicomponent melt spinning process has received considerable commercial interest owing to its potential applications in the production of various specialty fibers such as electrical conducting fibers, ultra-fine fibers and high-touch fibers[1]. It is well known that significant fiber structure development occurs during the high-speed spinning and that the structure and properties of the as-spun fibers strongly depend on the thermal and stress histories of the molten polymer in the spin-line[2]. Some recent studies[3,4] on the bicomponent fiber spinning of various polymer combinations have shown that the structure development in the individual components differ significantly from the corresponding single component spinning. In this study, the high-speed melt spinning was carried out for single and bicomponent fibers using Nylon 6 and PET. The structure changes of the individual components in the single and bicomponent fibers were investigated with respect to increasing take-up velocity.

2. EXPERIMENTAL

The sheath/core bicomponent fibers were prepared by extruding the melt of Nylon 6 (R.V. = 2.58) as the sheath and PET (IV = 0.63 dL/g) as the core through a concentric spinneret using two different extrusion systems. The concentrically combined polymer melts were extruded through a single hole spinneret 0.5 mm in diameter at 290°C and at a total mass flow rate of 6.0 g/min. Three different mass flow rate compositions were selected. They were: Nylon 6 : PET = 3:1, 1:1 and 1:3. The single component Nylon 6 and PET fibers were also prepared under similar conditions in the take-up velocity range

of 1–8 km/min. A noncontact diameter monitor was used for the diameter profile measurements. The structure of each component in the single and bicomponent fibers was analyzed through birefringence, wide-angle x-ray diffraction patterns, and DSC thermograms etc.

3. RESULTS and DISCUSSION

Fig. 1 shows the birefringence of the PET component of bicomponent fibers, mass flow rate combinations of 1:3, 1:1, and 3:1, together with the single component PET fiber. An increase in birefringence indicates a development of molecular orientation. The molecular orientation development of the PET in the bicomponent fiber was enhanced as compared to that of the single component fiber. With increasing take-up velocity, the birefringence for single and bicomponent fibers increases in sigmoidal type. The birefringence increases steeply around 3.5 km/min and tends to saturate around 6 km/min. For each take-up velocity, the molecular orientation of the PET component in bicomponent fiber increased with decrease in the PET composition. The birefringence of the Nylon 6 in bicomponent fibers for mass flow rate combinations of 1:3, 1:1, and 3:1 and that of the single component Nylon 6 fiber are shown in Fig. 2. The molecular orientation of the Nylon 6 component in bicomponent fibers was lower than that of the corresponding single component fiber. The PET component solidified at a temperature much higher than Nylon 6's glass transition temperature. Thus, the Nylon 6 component experienced stress relaxation and consequently orientation relaxation due to the solidified PET component. Fig. 3 shows the cold crystallization peak temperature of single component PET and the PET component in bicomponent fibers as a function of take-up velocity. It is widely known that the cold crystallization temperature decreases with increasing take-up velocity due to increased orientation. The cold crystallization temperature of the PET in the bicomponent fiber was decreased as compared to that of the single component fiber and the cold crystallization temperature of the PET component lowered with decrease in the PET composition. Fig. 4 shows the wide-angle X-ray diffraction (WAXD) patterns of the single component PET and those of 1:1 bicomponent fibers at take-up velocities of 5 and 6 km/min. The significant difference in the structural

development in the single component PET fiber and the PET component in bicomponent fibers is more evident from the wide-angle x-ray diffraction (WAXD) patterns of two samples at 5 km/min. The single component PET fiber shows vague crystalline reflections, however the PET component in the bicomponent fiber shows clear ones. The crystal formation of the PET in bicomponent fiber occurred at a lower take-up velocity than that of the single component PET fiber.

4. CONCLUSIONS

The high-speed melt spinning was carried out for the single and bicomponent fibers using Nylon 6 and PET. Change of fiber structure with increasing take-up velocity was investigated. The molecular orientation development and crystallinity of PET in the bicomponent fiber were enhanced as compared to that of the single component fiber and the molecular orientation of the PET component increased with decrease in the PET composition. On the other hand, the molecular orientation of the Nylon 6 component was lower than that of the corresponding single component fiber. The cold crystallization temperature of the PET in the bicomponent fiber was decreased as compared to that of the single component fiber and the cold crystallization temperature of the PET component lowered with decrease in the PET composition. The crystal formation of the PET in the bicomponent fiber occurred at a lower take-up velocity than that of the PET single component fiber.

5. REFERENCES

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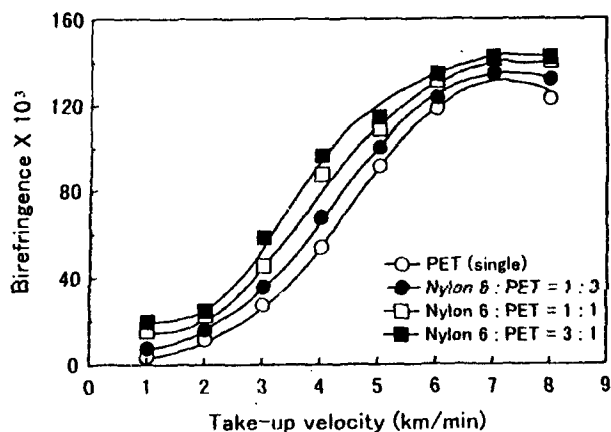


Fig. 1. Birefringence of single component PET and the PET component in bicomponent fibers as a function of take-up velocity for various Nylon 6 / PET mass flow rate combinations.

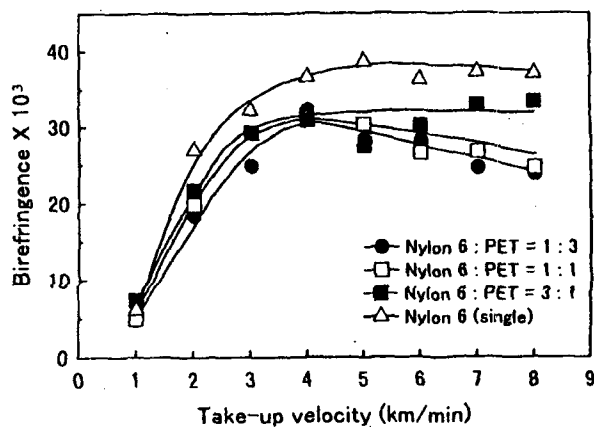


Fig. 2. Birefringence of single component Nylon 6 and the Nylon 6 component in bicomponent fibers as a function of take-up velocity for various Nylon 6 / PET mass flow rate combinations

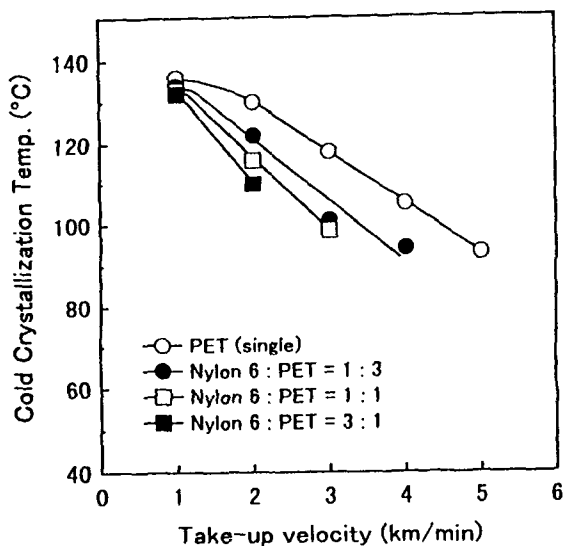


Fig. 3. Cold crystallization peak temperature of single component PET and the PET component in bicomponent fibers as a function of take-up velocity for various Nylon 6 / PET mass flow rate combinations.

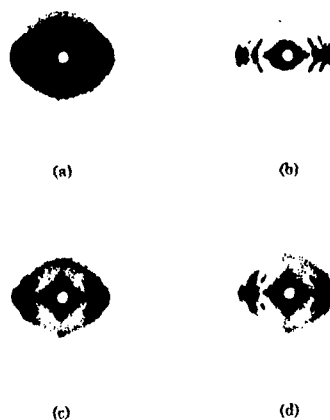


Fig. 4. Change in wide-angle X-ray diffraction patterns of as-spun fibers with take-up velocity : (a) PET, 5 km/min ; (b) PET, 6 km/min ; (c) Nylon 6 : PET = 1:1, 5 km/min ; (d) Nylon 6 : PET = 1:1, 6 km/min.