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Thermal property and miscibility of polycarbonate/copolyester blends

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SUMMARY

The thermal property and the miscibility of polycarbonate(PC)/copolyester blends were investigated. For the study, different copolyesters were synthesized from terephthalic acid (TPA) and various mixtures of ethylene glycol (EG) and cyclohexane dimethanol(CHDM). Various blends of PC and copolyester were prepared by melt mixing and thermal properties of the blends were studied employing differential scanning calorimeter. It was found that the blends of the PC and the copolyesters were partially miscible when the glycol in the copolyester was composed of 10, 20, or 30 mole % CHDM. However, the blends of the PC and the copolyesters were miscible in all proportions when the glycol in the copolyester was composed of 50 or 70 mole % CHDM. Miscibilities of the PC/copolyester blends depending on the composition of the copolyester are discussed based on the thermal properties of the blends.

INTRODUCTION

Recently, blends of bisphenol-A polycarbonate(PC) and various thermoplastic polyesters have been studied by many researchers(1-5). Poly(ethylene terephthalate) (PET) and poly(butylene terephthalate) (PBT) were reported to be partially miscible with PC(1,2). But, copolyesters formed from 1,4-cyclohexane dimethanol(CHDM) and terephthalic acid(TPA) or mixture of TPA and isophthalic acid were found miscible with PC in all proportions(3). Aliphatic polyesters were also reported miscible with PC in all proportions(4). According to Paul and his coworkers, ester exchange reactions between PC and copolyesters during melt mixing are not so important and miscible phase formations are due to physical interactions between the blend components(5). It is expected that the miscibility of a copolyester and PC is largely dependent on the CHDM content of the copolyester. However, there are few papers concerning the miscibility of PC and various copolyesters from TPA, CHDM, and ethylene glycol(EG), depending on the composition of the copolyester. Thus, we synthesized copolyesters of different compositions and the blends of PC and the copolyesters were investigated. The miscibilities of PC/copolyester blends are discussed in this paper based on the thermal properties of the blends.

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EXPERIMENTAL

The PC used was a commercial bisphenol A polycarbonate from Samyang Company designated TRIREX-3022 which has Mn=14,200 and Mw=42,500. Following the method described by Goodman, various copolyesters were synthesized by polycondensations of the oligomers obtained by transesterification of dimethyl terephthalate(DMT) and CHDM/EG(6). The characteristics of the copolyesters are given in Table-1. Blending of the copolyesters and the PC were carried out employing Roller Mixer of Brabender Plasticorder 331 for 3minutes at 250-270 ° C. There might be ester exchange reactions between the copolyesters and the PC during melt mixing. But, it was assumed that such reactions did not affect the miscibility of the blend significantly as pointed out by Paul and his coworkers(5). The blend ratios of PC/copolyester systems were 75/25, 50/50, and 25/75 by weight. Thermal properties of the blends were studied employing differential scanning calorimeter (DSC: DSC 951 of DuPont TA-2000). The samples were heated in DSC up to 270 ° C, held for 3 minutes and quenched to room temperature using liquid nitrogen. Then, the samples were scanned at 10 ° C/min to check the glass transition temperatures (T_g's), crystallizations, and melting behaviors of the blends.

RESULTS AND DISCUSSION

In Fig.1, DSC thermograms of the PC/copolyester(C-10) blends are shown. Two T_g's were observed in the PC/C-10 blends. Miscible polymer blends exhibit a single T_g between the T_g's of the pure components while, in partially miscible systems, two T_g's approach each other but do not become identical(7). The two T_g's in Fig.1 are due to PC-rich phase (higher T_g) and copolyester-rich phase(lower T_g). It is worthwhile to note that the higher T_g's are lower than the T_g of PC while the lower T_g's are almost the same as the T_g of C-10. It is speculated that the copolyester dissolves more in the PC-rich phase than does the PC in the copolyeste-rich phase. Li and Williams also reported two T_g's were observed in blends of PC and a copolyester the composition of which was not revealed(8). The PC/C-10(25/75) blend and the PC/C-10(50/50) blend showed crystallization exotherms and crystalline melting endotherms while the PC/C-10(75/25) blend did not. The crystallization of the copolyester seems to be depressed by the PC in the blends.

Table-1. Characteristics of Copolyesters Synthesized.

Sample Code	Molar Ratio of EG/CHDM	Mn	Mw
C-10	90/10	45,200	77,200
C-20	80/20	49,600	66,200
C-30	70/30	34,700	69,000
C-50	50/50	39,400	67,100
C-70	30/70	31,900	65,200

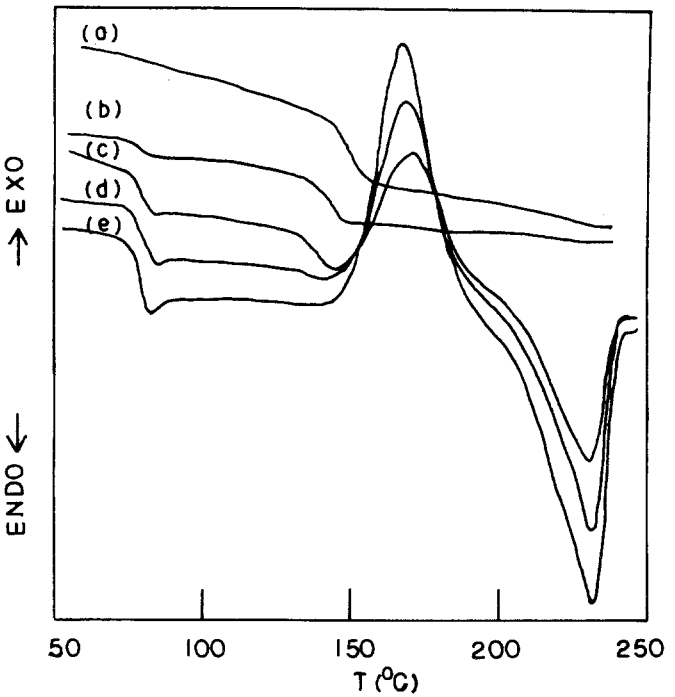

Fig. 1 DSC thermograms of the PC/C-10 blends in different compositions(by wt.): (a)100/0; (b)75/25; (c)50/50; (d)25/75; (e)0/100.

In Fig. 2, DSC thermograms of the PC/copolyester(C-20) blends are shown. The PC/C-20(25/75) blend showed single T_g and is believed to form miscible blend. However the PC/C-20(50/50) blend and the PC/C-20(75/25) blend showed two T_g's which are due to the PC-rich phase and the copolyester-rich phase as the PC/C-10 blends. It was also found that the T_g's of PC-rich phases were depressed more than those of the PC-rich phases in the PC/C-10 blends even though the T_g of the C-20 was almost the same as that of the C-10. It is believed that the miscibility of the PC and the copolyester was improved as the CHDM content of the glycols in the copolyester is increased from 10 to 20 mole %. It is of interest to note that the copolyester, C-20, did not show crystallization exotherm in the DSC thermogram. The crystallization of copolyester seems to be depressed as the CHDM content in the glycols of the copolyester is increased from 10 to 20 mole %.

In Fig. 3, DSC thermograms of the PC/copolyester (C-30) blends are shown. Thermal behaviors of the blends were similar with those of the PC/C-20 blends. But, it was observed that the T_g's of PC-rich phases were lowered and T_g's of copolyester-rich phases were increased compared with those of the PC/C-20 blends. Thus, it is believed that the miscibility of the PC and the copolyester is also improved as the CHDM content in the glycols of the copolyester is increased from 20 to 30 mole %. However, the PC/C-30 blends are still partially

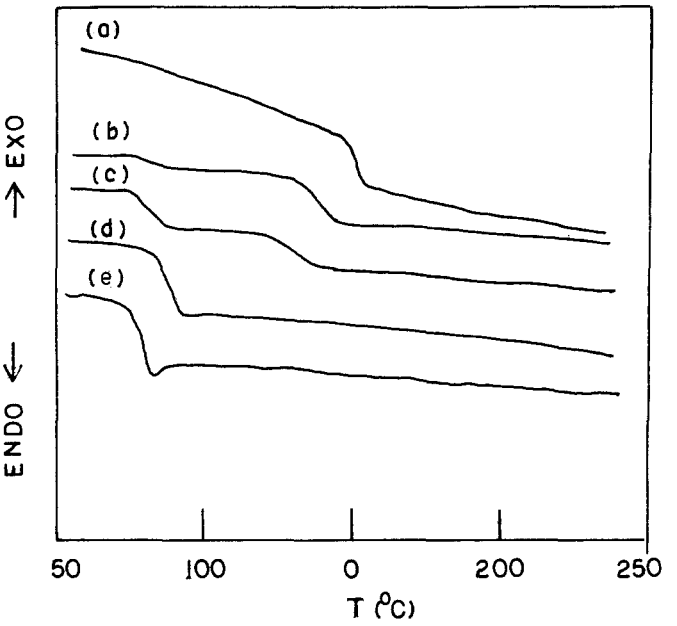

Fig.2 DSC thermograms of the PC/C-20 blends in different compositions(by wt.): (a)100/0; (b)75/25; (c)50/50; (d)25/75; (e)0/100.

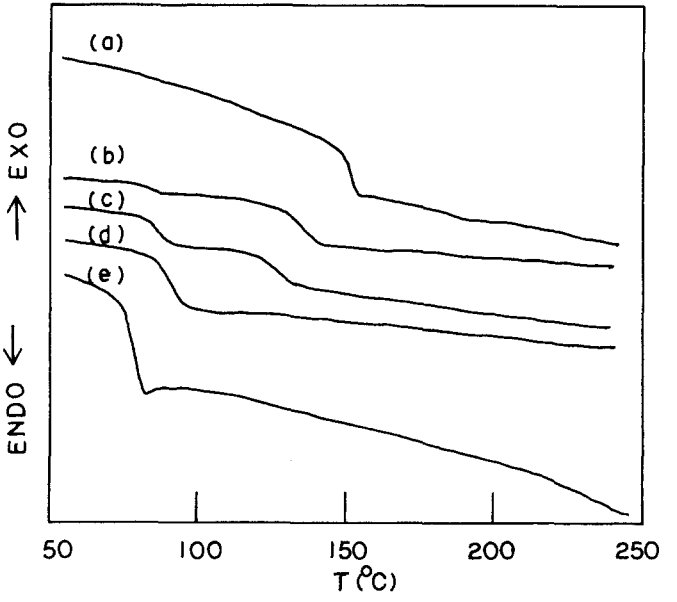

Fig.3 DSC thermograms of the PC/C-30 blends in different compositions(by wt.): (a)100/0; (b)75/25; (c)50/50; (d)25/75; (e)0/100.

miscible. It was also noted that the copolyester, C-30, did not show crystallization exotherm as the copolyester, C-20.

In Fig.4, DSC thermograms of the PC/copolyester(C-50) blends are shown. Single T_g was observed between T_g's of the PC and the copolyester, C-50. It is beli-eved that the PC/C-50 blends are miscible in all proportions. The copolyester C-50 did not show cystallization exotherm in the DSC thermogram as the copolyester, C-20 or C-30. In Fig.5, DSC thermograms of the PC/C-70 blends are shown. The PC/C-70 blends also showed single T_g's. The PC/C-70 blends are also believed to be miscible in all proportions. It is speculated that the blends of the PC and the copolyesters become miscible as the CHDM content in the glycols of the copolyester is increased from 30 to 50 mole % or more than 50 mole %. It is of interest to note that crystallization exotherm and crystalline melting endotherm were observed in C-70. But the blends did not undergo crystallization except the PC/C-70(25/75)blend.

CONCLUSION

Various copolyesters were synthesized and miscibilities of the PC/copolyester blends were investigated based on the thermal properties of the blends. It was found that the blends of the PC and the copolyesters (C-10, C-20, and C-30) are

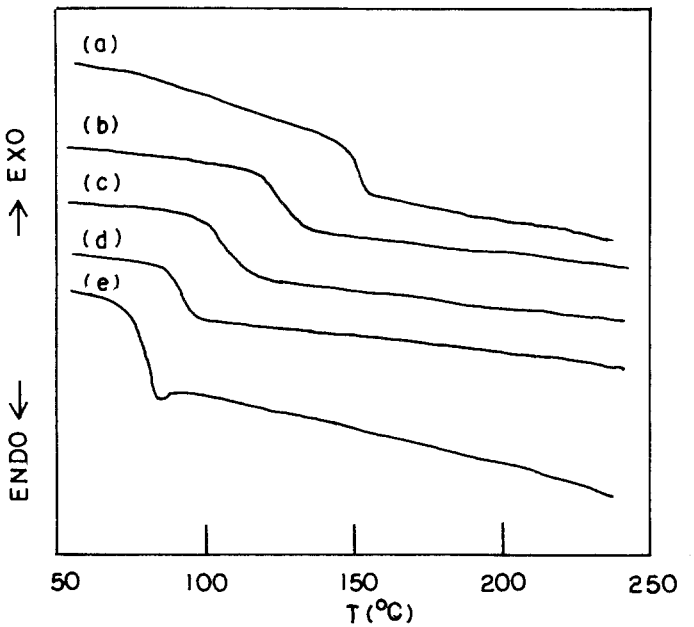

Fig.4 DSC thermograms of the PC/C-50 blends in different compositions(by wt.): (a)100/0; (b)75/25; (c)50/50; (d)25/75; (e)0/100.

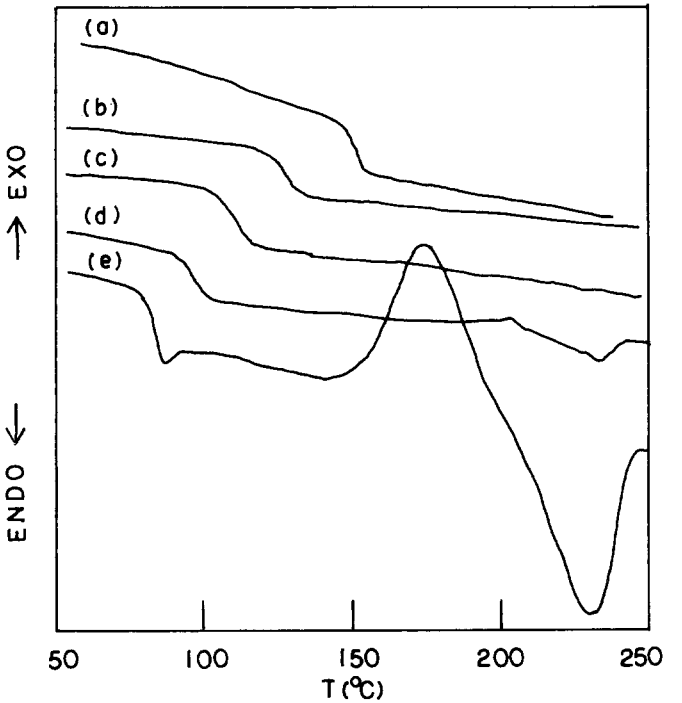

Fig.5 DSC thermograms of the PC/C-70 blends in different compositions(by wt.): (a)100/0; (b)75/25; (c)50/50; (d)25/75; (e)0/100.

partially miscible while the blends of the PC and the copolyesters (C-50 and C-70) are miscible in all proportions. It is concluded that the miscibility of the copolyester with the PC is improved as the CHDM content of the copolyester is increased.

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