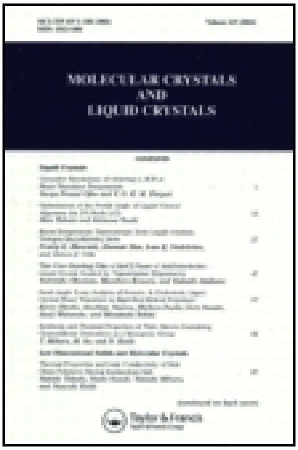

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Mechanical and Thermal Properties of PET/PBT Blends

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MECHANICAL AND THERMAL PROPERTIES OF PET/PBT BLENDS

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Poly (ethylene terephthalate) (PET)/poly (butylene terephthalate) (PBT) blends were prepared in ways: by injection molding only and by mixing on extrusion machine and than injection molding. The mechanical properties, thermal behavior and crystallization of PET/PBT blends were investigated. It has been observed that the ways of preparation of the blends have the biggest influence on their mechanical properties, especially on impact strength. The DSC study shows generally double melting endotherms and one crystallization exotherm. The study presents that mixing of PET and PBT only during the injection molding is not sufficient for expected, essential improvement of impact resistant of PET/PBT blends. To warranty the enhanced properties of the injected PET/PBT blends it is necessary to mixed them first on the extrusion machine.

Keywords: mechanical and thermal properties; PET/PBT blends

INTRODUCTION

Polymer blends are now of great scientific and industrial interest. In the search for new polymeric materials, blending of polymers is a method for obtaining new desirable property combinations without having to synthesize novel structures.

Poly (ethylene terephthalate) PET and poly (butylene terephthalate) PBT have been known for many years as engineering plastics with many desired properties. PET has excellent chemical resistance and good mechanical and electronic properties. PBT is one of the engineering polyesters with highest crystallization rate. The PET/PBT blends are of special interest as they exhibit many good chemical, mechanical and thermal features.

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Several blends of PET and PBT have been studied extensively before by: Avramowa, Papadopoulov, Pillon, Robeson and Saheb [1–7]. The big interest of PET/PBT blends results from practical implications.

The aim of this paper is to investigate the thermal and mechanical properties of PET/PBT blends obtained in two ways: first – by injection molding and second – mixed on extrusion machine and than injected.

EXPERIMENTAL

Commercial engineering grade polymers: PET-(9921W-Eastman Chemicals) and PBT-(Vestodur X7085- Degusa Huls AG) were used in the research. Two types of the blends were prepared: one by injection moulding using the Engel machine ES 80/20HLS with L/D = 18 and D = 22 mm, and the second mixed at first by extrusion moulding machine Fairex with L/D = 24 and D = 25 mm and then injected on the Engel machine. The processing temperature has been in the range from 225°C to 255°C for injection moulding and in the range from 180°C to 240°C for extrusion. The injection pressure was 900 bar and the pack pressure 600 bar, the extrusion pressure was 300 bar. The following PET/PBT blends were prepared: (100/0; 95/5; 90/10; 80/20; 70/30; 50/50; 25/75; 0/100 wt./wt.).

The tensile strength and elongation have been measured on INSTRON - 1115 tensile machine, Charpy's impact strength on impact hammer INSTRON-PW5 and Brinell hardness on the hardness equipment HPK8206. The thermal analysis was performed on Polymer Laboratories differential scanning calorimeter (DSC) and all scans were conducting at heating rate 10°C/min.

RESULTS AND DISCUSSION

The results of mechanical properties of the tested PET/PBT blends are presented at drawings 1–4. Figure 1 show almost the constant value of tensile strength for both types of blends (58–62 MPa for injected blends and 54–58 MPa for first extruded and than injected blends). On the Figure 2 we can see that elongation decreases from 76% to 37% for first type of PET/PBT blends and from 93% to 52% for second type with increasing the PBT share in the blends.

From Figure 3 we can see that Brinell hardness is much higher for extruded and injected blends (76–78 N/mm^2) than only for injected blends (44–54 N/mm^2). For both blends the hardness increase with increasing the PBT share in the blends.

The ways of preparation of the blends have the strongest influence on impact strength. As we can see on the Figure 4 the impact strength of

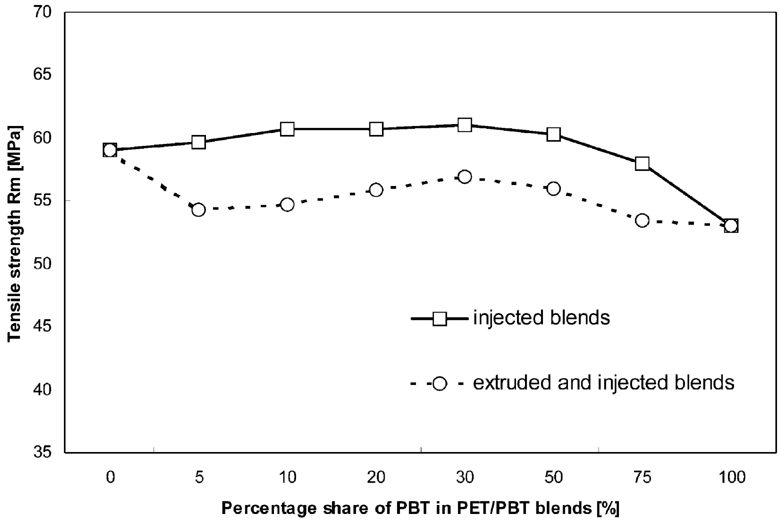

FIGURE 1 Tensile strength of PET/PBT blends.

PET/PBT blends first extruded and than injected is three times higher (from 15 to 12 kJ/m^2) to compare with only injected blends (from 5 to 3 kJ/m^2). Figure 4 shows also that impact strength of the blends increase with increasing PBT share in the PET/PBT blends.

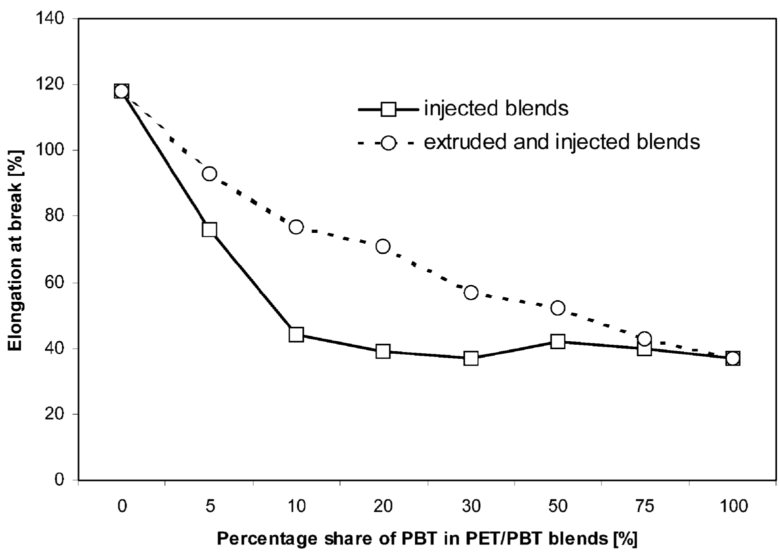

FIGURE 2 Elongation at break of PET/PBT blends.

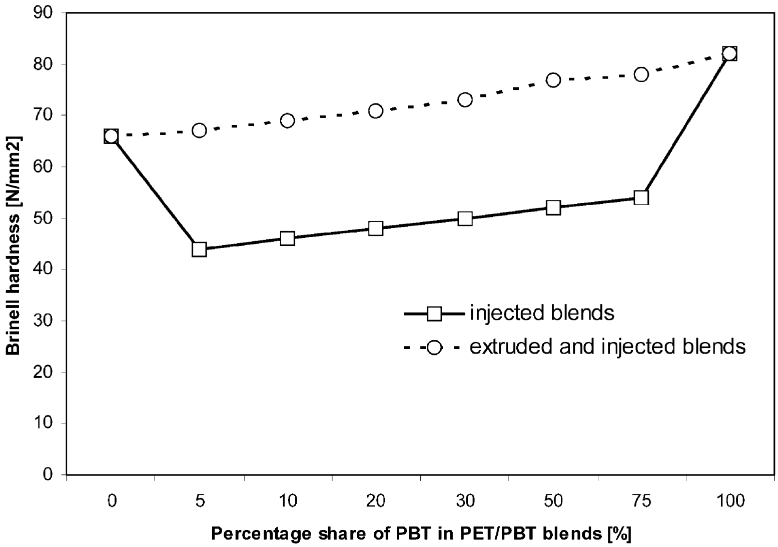

FIGURE 3 Brinell hardness of PET/PBT blends.

Summarizing the results of investigation the mechanical properties of PET/PBT blends, it's clearly see that adding the PBT material into PET we are decreasing the elongation of prepared blends, keeping almost constant values of tensile strength and increasing the hardness and impact

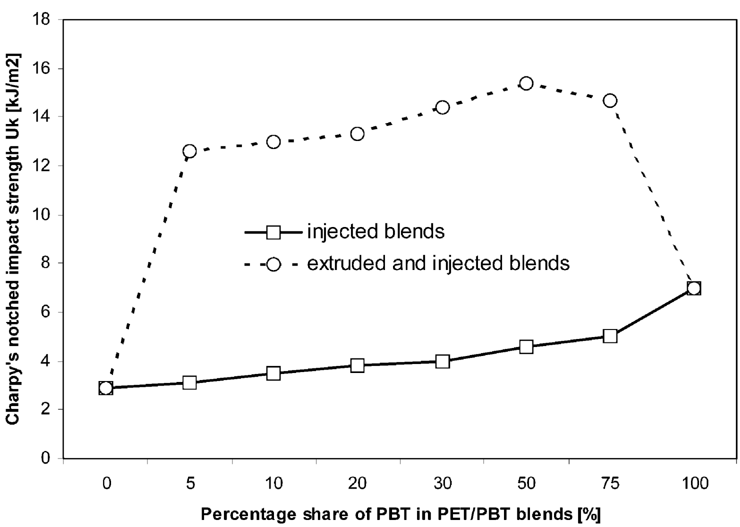

FIGURE 4 Charpy's notched impact strength for PET/PBT blends.

strength. It can be see also, that the way of preparation of blends has stronger influence on the properties than PBT share in them.

The data of DSC study for both blends are shown in Tables 1 and 2.

The DSC study shows double melting peaks: one around at 225°C (responsible for PBT), and the second one around 252°C (responsible for PET). It has been observed also one crystallisation peak in the temperature range between 216°C and 190°C. The crystallization temperature is decreasing with increasing the PBT share ratio in the PET/PBT blends.

DSC study allowed also to determine the crystallinity of the polymers and their blends. The measured crystallinity of the clear PET was 16% and 36% for clear PBT. The injected blends have the crystallinity between 18 to 30% (higher value for higher share ratio of PBT) while the extruded and injected blends between 20 to 32% (also higher crystallinity for higher amount of PBT in PET/PBT blends).

Generally introducing the PBT material into PET increase the crystallisation speed what result in decreasing the crystallization temperature and increasing the crystallinity. That features improve and make much easier the processing of PET/PBT blends.

The study shows that mixing of PET and PBT only during the injection moulding is not sufficient for obtaining expected, essential improvement of impact resistant of PET/PBT blends. To warranty the enhanced properties of the injected PET/PBT blends it is necessary to mixed them first on the extrusion machine. Prepared in such a way PET/PBT blends have much

TABLE 1 Melting and Crystallization Temperature and Crystallinity for Injected PET/PBT Blends

	Percentage share of PBT in PET/PBT blends [%]				
Data of DSC study	90/10	80/20	70/30	50/50	25/75
Crystallization temp. beginning T_{ca} [°C]	194,6	192,1	188,1	171,2	173,8
Crystallization temp. finishing T_{cb} [°C]	218,1	228,4	198,3	212,3	198,1
Crystallization temperature T_c [°C]	208	215,7	205,4	189,4	189,4
Melting temp. beginning T_{ma}, [°C]	227,1	207,6	207,8	202,3	202,4
		220	235	236,8	237,5
Melting temp. finishing T_{mb}, [°C]	261,7	220	235	235	237,1
		298,4	259,9	258,7	259,1
Melting temperature T_m, [°C]	253,7	223,4	226,4	225,7	227
		253,2	254,7	252,1	248,4
Enthalpy changing ΔH_m, [J/g]	– 34,97	– 2,468	– 6,665	– 17,89	– 31,34
		– 22,33	– 26,94	– 21,00	– 8,434
Weight of samples, [mg]	5,700	7,200	8,600	7,900	6,000
Crystallinity, [%]	18,43	20,54	27,39	30,28	29,17

TABLE 2 Melting and Crystallization Temperature and Crystallinity for Extruded and Injected PET/PBT Blends

	Percentage share of PBT in PET/PBT blends [%]				
Data of DSC study	90/10	80/20	70/30	50/50	25/75
Crystallization temp. beginning T_{ca} [°C]	181,9	197,1	194,3	173,6	179,1
Crystallization temp. finishing T_{cb} [°C]	220,0	226,8	222,9	224,1	206,3
Crystallization temperature T_c [°C]	205,8	213,5	210,9	190	191,9
Melting temp. beginning T_{ma}, [°C]	223,9	229,2	203,8	229,6	207,8
		234,9	235,0	235,3	236,1
Melting temp. finishing T_{mb}, [°C]	264,1	235,0	235,1	235,4	236,1
		258,1	259,9	260,8	255
Temp. of melting T_m, [°C]	254,3	224,0	224,0	226,4	225,2
		252,9	253,2	253,5	250,7
Enthalpy changing ΔH_m, [J/g]	37	– 9,536	– 8,652	– 15,68	– 32,7
		– 21,14	– 19,76	– 19,68	– 10,5
Weight of samples, [mg]	7,900	7,200	7,300	6,800	6,400
Crystallinity, [%]	19,50	24,52	22,74	27,61	31,42

better mechanical properties than only injected. The properties improvement of such a blends turned out so big that many producers (i.e. Schulman or PolyOne) supplied ready made commercial PET/PBT blends. They list the material's advantages of PET/PBT blends as: higher mechanical and thermal properties, better flow, lower shrinkage and better surface than comparable PBT only compounds.

CONCLUSIONS

1. Study presents that mixing of PET and PBT only during the injection molding is not sufficient for expected, essential improvement of impact resistant of PET/PBT blends. To warranty the enhanced properties of the injected PET/PBT blends it is necessary to mixed them first on the extrusion machine.
2. It has been observed that the ways of preparation of the blends have the big influence on their mechanical properties, especially on impact strength.
3. The impact strength of PET/PBT blends first extruded and than injected is three times higher (from 12 to 15 kJ/m^2) to compare with only injected blends (from 3 to 5 kJ/m^2).
4. The crystallization temperature is decreasing (from 216°C to 190°C) with increasing the PBT share ratio in both types of PET/PBT blends.

5. The DSC study shown significant increase of crystallinity with increasing PBT share in PET/PBT blends.
6. The double melting temperature for both types of blends, reflect the fact that PET and PBT is only partly miscible.

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