Journal of Thermal Analysis and Calorimetry, Vol. 86 (2006) 1, 155–164

DETERMINATION AND COMPARISON OF THE ESSENTIAL WORK OF FRACTURE (EWF) OF TWO POLYESTER BLENDS

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The fracture toughness of blends of polypropylene terephthalate (PPT) with polyethylene terephthalate (PET) and polybutylene terephthalate (PBT) were investigated. Binary blends were prepared comprising 10:90, 30:70, 50:50, 70:30 and 90:10 mass/mass%. The fracture toughness was determined for each blend using the essential work of fracture (EWF) method and thin film double edge notched tension (DENT) specimens. The specific essential work of fracture, w_e, values obtained for blends of PET/PPT ranged from 27.33 to 37.38 kJ m^{-2} whilst PBT/PPT blends yielded values ranging from 41.78 to 64.23 kJ m^{-2}. Differential scanning calorimetry (DSC) was employed to assess whether or not crystallinity levels influence the mechanical properties evaluated. The fracture toughness of PPT deteriorated with PET incorporation. However, high w_e values exceeding that of pure PPT were obtained for PBT/PPT blends across the composition range studied.

Keywords: *copolyesters, essential work of fracture (EWF), terephthalates*

Introduction

The two polyester blends, PPT/PET and PPT/PBT, investigated were prepared using pure polyester resins in an attempt to identify new materials for potential application in the medical device and packaging industry. The pure materials were also tested for fracture toughness using the EWF method by way of comparison [1]. Previous work concluded that, for the grades considered, PPT displayed greater fracture toughness than either PET or PBT, thus raising the possibility of its utilisation in thin film applications.

Theory of the EWF method

The essential work of fracture method is based on the theory suggested by Broberg [2, 3]. Other workers, for example Cotterell *et al*. [4], have developed the method still further. The EWF method involves the separation of the energies of fracture into two categories, i.e. (*i*) energy associated with elastic tearing at the crack tip and (*ii*) energy associated with plastic deformation away from the crack which does not contribute directly to fracture.

The total work of fracture, W_f, is the sum of the elastic and plastic energy contributions, as shown in Eq. (1):

$$W_f=W_e+W_p \tag{1}$$

where W_e is the essential work of fracture and W_p is the non-essential work of fracture. Equation (1) may be rewritten as:

$$W_f=w_e lt+w_p\beta l^2 t \tag{2}$$

where w_e is the specific essential work of fracture, w_p the specific non-essential work of fracture, l is the ligament length, t the specimen thickness and β is the shape factor associated with the shape of the plastic zone. The specific total work of fracture, w_f, of a ductile material can be expressed by simplifying Eq. (2):

$$w_f=w_e+\beta w_p l \tag{3}$$

The specific essential work of fracture represents an intrinsic property of a material for a given thickness. However, this is not true in the case of βw_p. The integral of the load (P)-displacement (δ) curve obtained for the ductile fracture of specimens of different ligament length represents a value for W_f. The value for the specific essential work of fracture, w_e, is obtained by extrapolating the line obtained when plotting w_f *vs*. l to zero. The slope of this line gives the value for βw_p [1].

Validity of the EWF method

For w_f to vary linearly with l a state of pure plane stress, or plane strain, must be met. This condition is typically fulfilled in the case of the plane stress state when the ligament length comprises values within a given valid range. The lower boundary for the ligament length has a value of 3 to 5 times the thickness of the specimen [4–16]. If the ligament length value drops below this limit a transition state from plane stress to

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1388–6150/$20.00

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plane strain is met and the linearity between w_f and l is lost as l approaches zero. An upper limit for the ligament length also exists, representing a value corresponding to a third of the specimen's width w, or twice the plastic zone size, r_p, whichever is lowest [4–16]. Equation (4) is used to calculate r_p:

$$2r_p = (Ew_e)/(\pi\sigma_y^2) \tag{4}$$

where E is the Young's modulus and σ_y the yield stress.

A second requirement has to be considered to confirm a state of pure plane stress. Many studies [6–12, 15–18] on the fracture of DENT polymer specimens demonstrate that pure plane stress is reached when the net-section stress at maximum load, σ_n, lies below 1.15 σ_y. Equation (5) is used to determine σ_n:

$$\sigma_n = P_{max}/(tl) \tag{5}$$

where P_{max} is the maximum load recorded at the yield point.

Previous research

The essential work of fracture method has been applied extensively in studying PET and PBT [5, 6, 9–11, 13–16, 19]. However, to date, the authors' previous article on the fracture toughness of PPT [1] appears to be the only published work available on this polyester. No studies on blends of PPT with PET or PBT have been reported.

Hashemi [5] studied the fracture toughness of PET and elicited that w_e is an intrinsic material property for a given thickness, whereas βw_p is dependent on the specimen geometry. The effect of specimen geometry on the fracture toughness of PBT was also investigated [10]. Single edge notched tension (SENT) geometry produces higher βw_p values relative to DENT specimens. Chan *et al*. [6], in their study on PET, confirmed that w_e is an intrinsic property of the material and independent of the specimen width. Additionally, this study demonstrated that w_e is not affected by the deformation rate.

In the case of PBT, Hashemi [9] demonstrated that w_e increases slightly with the deformation rate whilst βw_p decreases.

Furthermore, w_e is independent of specimen orientation, while fracturing perpendicular to the extrusion direction yields higher values for βw_p [16].

Hashemi [9, 10, 16] indicates that for the fracture of PBT SENT specimens the value of w_e is not significantly influenced by specimen thickness, whereas βw_p decreases when the thickness increases.

Arkhireyeva *et al*. [14, 15] studied the influence of temperature on the fracture parameters of PET. Below the glass transition temperature, T_g, of the polymer w_e does not show any sign of variation with temperature. The value of w_e then rises to a maximum before falling with increasing temperature [14]. A maximum value for βw_p also appears at the T_g. Hashemi [11, 16] obtained similar results for PBT. Indeed, the value of w_e is unaffected by temperature up to the T_g with a decrease occurring at higher temperatures.

Karger-Kocsis *et al*. [19] studied the fracture toughness of three amorphous copolyesters of different entanglement densities. Contrasting tendencies for cold crystallisation were observed.

The following considers blends of PET/PPT and PBT/PPT. It was of interest to investigate whether or not the fracture toughness of PPT could be improved by blending it with its close polyester homologues.

Experimental

Materials

The three materials considered were pure resins with no fillers or additives. The PET used was a commercial grade Melinar TS5 LASER+® obtained from Dupont Polyester (Wilton, Redcar, UK) possessing an intrinsic viscosity (*i.v.*) value of 0.84 dL g^{-1}. PPT was obtained from Shell Chemicals Belgium S.A. (Louvain-la-Neuve, Belgium). The grade chosen was Corterra® CP509211 (*i.v.*=0.92 dL g^{-1}). Pocan® B1300 (*i.v.*=0.95 dL g^{-1}), a pure PBT resin, was received from Bayer A.G. Germany. The *i.v.* values were confirmed by dilute solution viscometry and viscosity average molecular mass values (M_v) were calculated for each polyester [1]. The three polymers exhibited similar M_v values. The homopolymers were dried overnight in a vacuum oven at 150°C. Polyblends were prepared in different compositions by blending the two components at 280°C using a small-scale twin-screw extruder (DSM Midi-Extruder, capacity 18 cm^3, screw length 150 mm and screw speed 50 rpm). The extruded materials were immediately quenched in cold water before drying and grinding into a fine powder using a lap top micronisation unit for optimal film homogeneity.

Specimen preparation

Compression moulding of the blends into thin films (t~0.13 mm) was accomplished using a heated press (Mackey Bowley C10888/98) at 260°C. Each type of test required specimens with different dimensions. These were prepared using an appropriate stencil and precision cutting tool sporting a fresh blade. Dimensions consistent with 45×50 mm were chosen for the fracture test specimens. The same cutting tool was used to prepare DENT specimens. Two aligned notches of various depths were cut halfway down each side of the rectangular samples. The upper limit for the ligament length range was set at one third the specimen width. Values of 5 t and 0.30 mm were adopted for the lower boundary corresponding to the ligament length and thickness, respectively, to guarantee a safe lower limit for l. The valid ligament length range was calculated as:

$$1.5\leq l\leq 15\ \text{mm}$$

For practical convenience, the lower limit was assigned so that it was equal to 2 mm. Notches of ten different depths were adopted between the values corresponding to 15 and 21.5 mm.

Tensile samples were prepared according to the ASTM D882 standard. Specimens with dimensions of 20×130 mm were used for the determination of the Young's modulus.

Measurement of the yield stress test was carried out using 35×50 mm samples. Dumb-bell shaped specimens were prepared by punching two half circles (20 mm in diameter) half way down each side of the samples.

The exact thickness of each specimen was measured at different points using a micrometer and an average value recorded.

Testing

A Lloyd LRX tensile testing instrument was utilised for all mechanical tests at a deformation rate of 1 mm min^{-1}. Proprietary software (Nexygen from Lloyd Instruments Ltd.) was employed to record and integrate the data. For every test, an average value was taken from seven replicates.

A gauge length of 30 mm remained after fracture test specimens were gripped by the jaws of the instrument, and the P–δ curve was thereby recorded. Dividing the integral of P–δ by the loaded area gave a value for w_f. Ten different ligament lengths yielded ten distinct average values for w_f. The latter were plotted *vs.* l to allow both w_e and βw_p to be deduced.

In the case of the measurement of the Young's modulus, each long strip was loaded onto the instrument and its P–δ curve recorded. The initial slope was given by the software and a value for E obtained. Similarly, a P–δ curve was recorded for each dumb-bell shaped specimen. The value for the maximum load at yield allowed σ_y to be calculated.

DSC analysis

A PerkinElmer DSC 7 analyser was employed to investigate the PBT/PPT blends. DSC analysis was not performed on blends of PET/PPT since there was no noticeable improvement between their mechanical properties and those for the individual pure components. As the analyser was equipped with a cooling system each thin film sample (10 mg) was subjected to an initial heating scan from –30 to 290°C at 20°C min^{-1}.

Results

PET/PPT blends

Young's modulus

The Young's modulus values for PET/PPT blends are plotted *vs.* % PPT in Fig. 1.

A marginal decrease in the value of E occurs on comparing pure PET with the 70:30 PET/PPT blend. An unexpected rise in the value of E in the case of the 50:50 blend is also observed. Finally, Fig. 1 displays a steady decrease in the elastic modulus value as the PPT content of the blend increases.

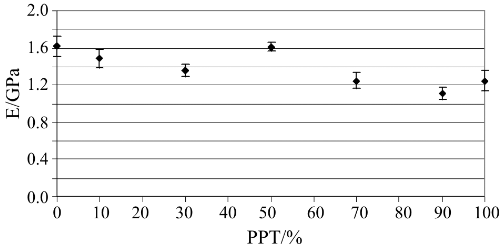

Fig. 1 E *vs.* PPT% for PET/PPT blends

Yield stress

Yield stress values for PET/PPT blends are plotted *vs.* PPT% in Fig. 2.

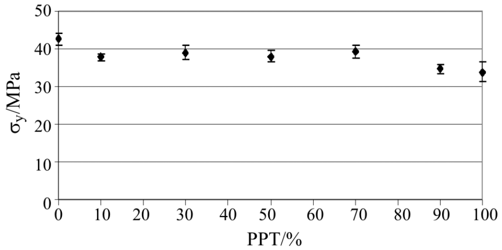

Fig. 2 σ_y *vs.* PPT% for PET/PPT blends

Specific works of fracture

Fracture test results for blends of PET/PPT are shown in Fig. 3.

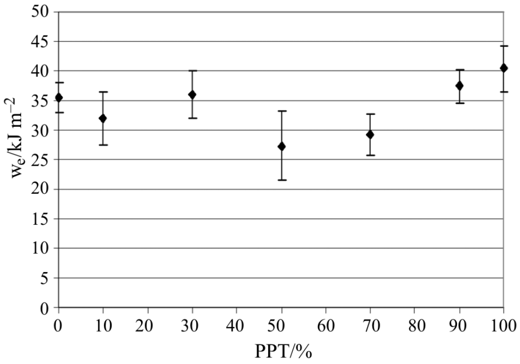

Fig. 3 Specific essential work of fracture values for PET/PPT blends with increasing PPT content

Values of w_e for the PET/PPT blends range from 27.33 to 37.38 kJ m^{-2}. A linear progression of w_e values with increasing PPT content rising from the w_e for PET to the higher w_e figure of PPT might have been expected. However, blending PET with 10% PPT lowers w_e from 35.54 to 32.02 kJ m^{-2}. The 70:30 PET/PPT blend displays a w_e value almost equal to that of pure PET. The 50:50 compositions in turn results in a drop in the w_e observed, followed by a near linear increase in w_e for each subsequent blend up to the w_e of pure PPT.

βw_p values, related to the plastic deformation of the PET/PPT blends, are plotted *vs*. % PPT in Fig. 4.

A linear decrease in βw_p values accompany an increase in the PPT content; all except for the 50:50 blend which appears anomalous.

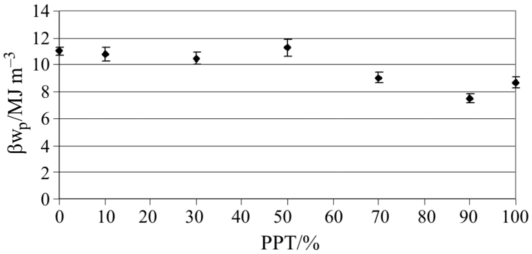

Fig. 4 βw_p *vs*. PPT% for PET/PPT blends

Net section stress condition

As mentioned earlier, the results of this study were only deemed to be valid under the state of pure plane stress. This state is ensured if the net-section stress is $\sigma_n \leq 1.15\ \sigma_y$. The average net-section stress has been calculated for each ligament length and plotted *vs*. the ligament length for the PET/PPT blends at each composition (Fig. 5).

Almost all σ_n values lie below 1.15 σ_y. This suggests that the tests have been carried out under a state of pure plane stress. In the case of the 10:90 composition, one σ_n value is higher than the 1.15 σ_y limit (Fig. 5a). Nevertheless, this value has still been considered in the determination of w_e. Indeed, by plotting a new graph without this deviation a poorer correlation factor, R^2 (from 0.9857 to 0.9829), results. Hence the contention that the deviation is in fact acceptable and leads to a more accurate determination of w_e and βw_p for the particular blend concerned.

Valid ligament length range

After testing was concluded, the value of the plastic zone size could be calculated together with the value of w_e for each material.

The calculated $2r_p$ values are listed in Table 1.

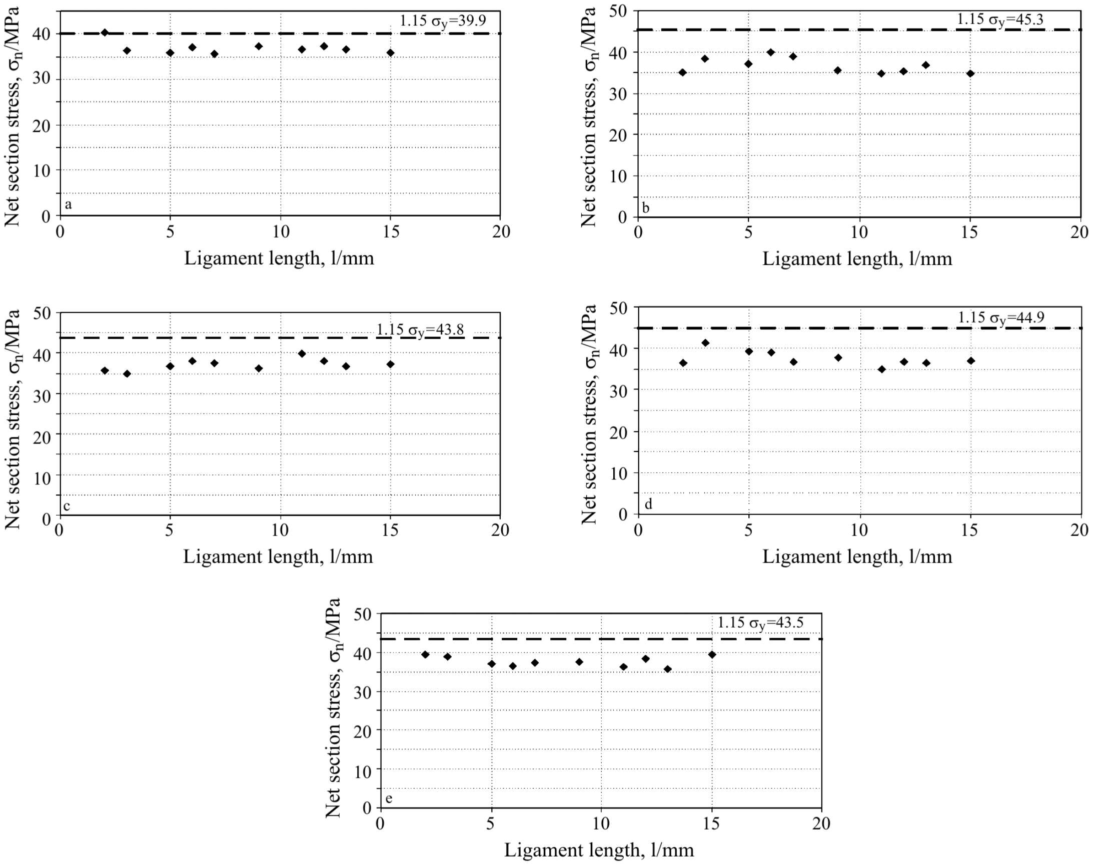

Fig. 5 Plots of σ_n vs. l for PET/PPT blends of different composition: a – 10:90, b – 30:70, c – 50:50, d – 70:30 and e – 90:10

Table 1 $2r_p$ values for PET/PPT blends

	10:90	30:70	50:50	70:30	90:10
$2r_p$/mm	11.0±1.2	7.50±1.1	9.65±2.2	10.2±1.4	10.6±1.7

At each composition the value of $2r_p$ is found to be less than w/3 and should therefore have been chosen as the upper limit for the ligament length range. However, all plots of w_f *vs*. l do not display significant signs of deviation from linearity for values of l between $2r_p$ and w/3. The $2r_p$ value limit is considered too restrictive and w/3 (15 mm) has alternatively been chosen as the upper limit of the ligament length range. Other workers have also faced the same dilemma [7, 12, 13].

PBT/PPT blends

Young's modulus

Young's modulus values measured for blends of PBT/PPT are given in Fig. 6.

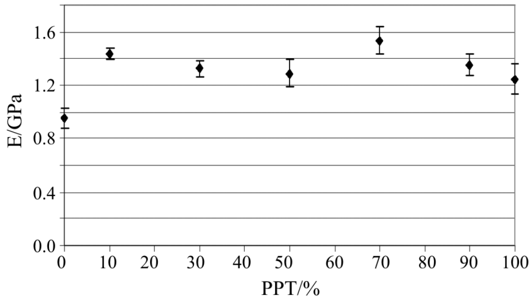

Fig. 6 E *vs*. PPT% for PBT/PPT blends

After an initial rise in the value of E corresponding to the 10% PPT composition a gradual decrease is observed up to and including the 50:50 blend. A second sudden increase at the 70:30 composition is followed by a final gradual drop in E reaching the value for pure PPT.

Yield stress

The yield stress values for PBT/PPT materials are presented in Fig. 7.

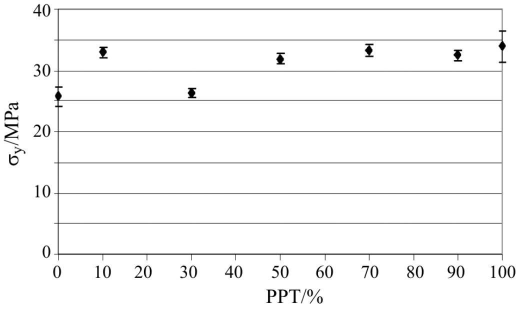

Fig. 7 σ_y *vs*. PPT% for PBT/PPT blends

Specific work of fracture

Specific work of fracture test results for PBT/PPT blends are presented in Fig. 8.

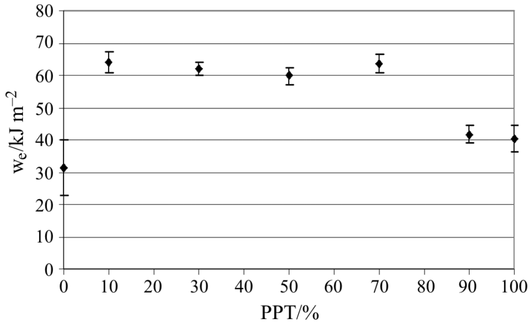

Fig. 8 Specific essential work of fracture values for PBT/PPT blends with increasing PPT content

PBT/PPT blends display w_e values ranging from 41.78 to 64.23 kJ m^{-2}. These values are greater than those corresponding to either of the pure components [1].

Values for βw_p, related to the plastic deformation of PBT/PPT blends, are plotted *vs*. PPT% in Fig. 9.

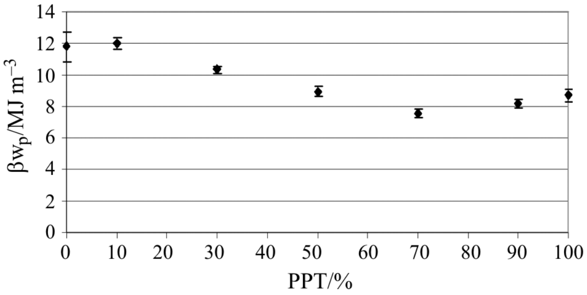

Fig. 9 βw_p *vs*. PPT% for PBT/PPT blends

The plot of βw_p increases slightly at the 10% PPT composition level. Thereafter, a decrease occurs as the PPT content is increased to 70% before rising to the βw_p value corresponding to pure PPT.

Net-section stress condition

Net-section stress values for the corresponding PBT/PPT blends are plotted *vs*. ligament length in Fig. 10.

Figure 10 shows that four of the five blends have σ_n values higher than the 1.15 σ_y limit, demonstrating the restrictive nature of the net-section stress condition. Once again, rejecting these data results in poorer correlation factors in the determination of w_e and βw_p. These values were therefore retained.

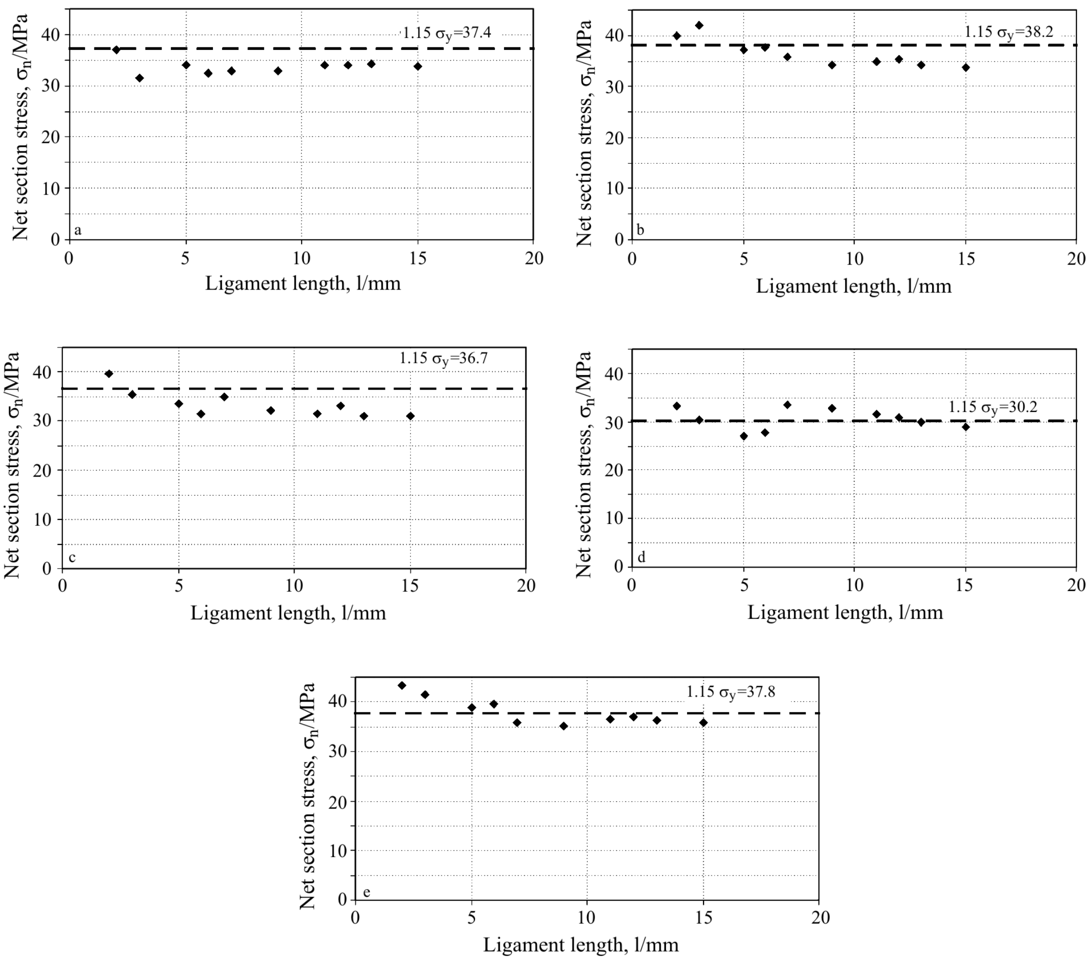

Fig. 10 Plot of σ_n *vs. l* for PBT/PPT blends of different composition: a – 10:90, b – 30:70, c – 50:50, d – 70:30 and e – 90:10

Valid ligament length range

Calculated $2r_p$ values are listed in Table 2.

At each composition the $2r_p$ value is higher than the corresponding value for *w*/3. In this case, the upper limit of *w*/3 (15 mm) is taken to be the ligament length range.

DSC analysis

DSC scans for pure PPT and PBT are available elsewhere [1]. Figures 11–15 present DSC data for PBT/PPT blends at the various compositions considered.

The main purpose in conducting the DSC investigation was to evaluate the level of crystallinity of each blend in an attempt to explain their promising mechanical properties. All blends show signs of physical ageing. This occurred at ambient temperature during the interval between mechanical testing and DSC analysis. A peak corresponding to the enthalpy of relaxation is observed at the glass transition temperature. This peak disappears on reheat scans (not shown here) conducted after rapid quenching. The apparent level of crystallinity of individual samples has been calculated using the enthalpy difference (ΔH_d)

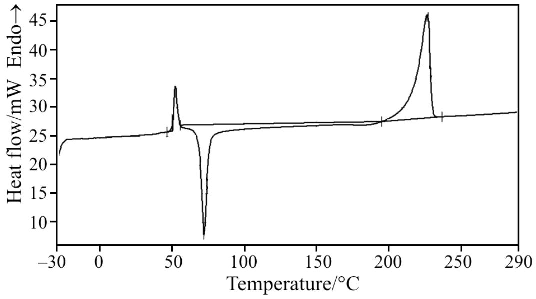

Fig. 11 DSC heating trace corresponding to 10:90 PBT/PPT blend

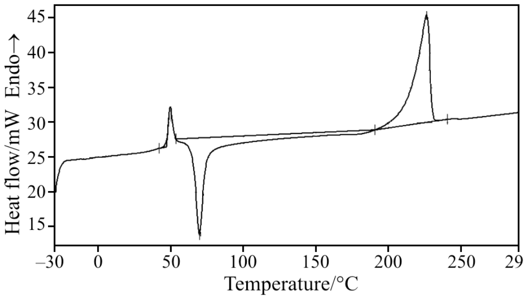

Fig. 12 DSC heating trace corresponding to 30:70 PBT/PPT blend

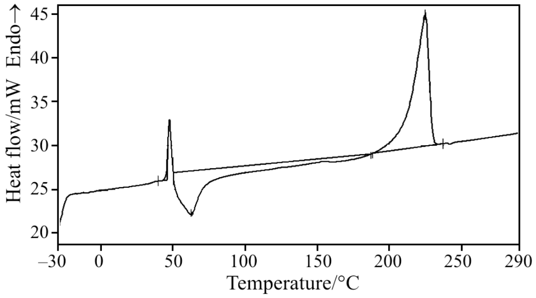

Fig. 13 DSC heating trace corresponding to 50:50 PBT/PPT blend

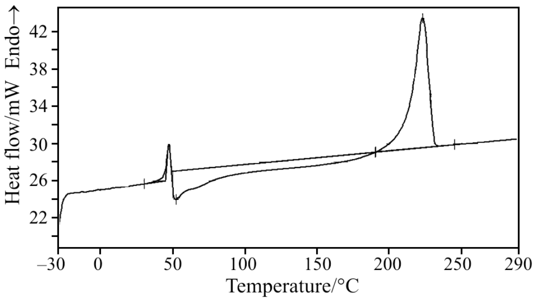

Fig. 14 DSC heating trace corresponding to 70:30 PBT/PPT blend

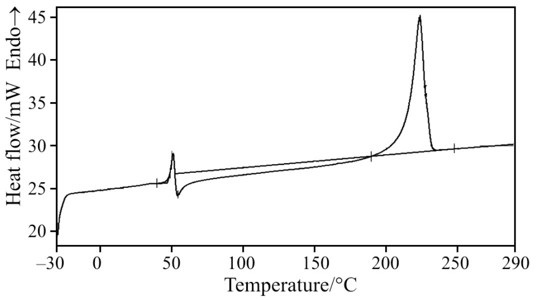

Fig. 15 DSC heating trace corresponding to 90:10 PBT/PPT blend

between the melting and cold crystallisation peaks and dividing this by the heat of fusion (ΔH^0) of the material. PPT and PBT share the same value for their heats of fusion [20]. It is assumed that a blend of the two polyesters would comprise the same value. Table 3 displays the data in question along with the glass transition temperature for each composition.

Discussion

PET/PPT blends

Young's modulus

A gradual decrease in the value of E is expected with increasing PPT content (Fig. 1). This occurs for all PET/PPT blends except for the 50:50 sample. In this case, a sudden increase in E results. It is suggested that the blend in question might be the least inclined to undergo plastic deformation alternatively fracturing in a brittle fashion instead – a hypothesis that is in full agreement with the experimental data from the fracture tests.

Yield stress

Yield stress, σ_y, values lie between those of the pure components constituting the blends and are only slightly affected by the PPT content (Fig. 2).

Specific essential work of fracture

Figure 3 shows that w_e values recorded for the blends concerned are generally lower than the corresponding values for the two pure components. In particular, the w_e values for all five blends lie below the w_e figure for pure PPT. This suggests that the constituent blend polyesters 'hinder' each other resulting in materials with poorer resistance to fracture. Blending PET with PPT may have increased the level of crystallisation of both polymers resulting in more brittle materials which would account for the lower value of w_e observed.

Specific non-essential work of fracture

With the exception of the 50:50 composition, a linear decrease in βw_p values is observed with increasing PPT content (Fig. 4). It is also noteworthy that the highest βw_p value occurs in conjunction with the lowest value of w_e, in the case of the 50:50 blend, suggesting that more plastic deformation takes place at this composition. Any hypothesis suggesting that the 50:50 blend shows more brittleness is therefore not considered valid.

Net-section stress condition

Only one σ_n value lies above the 1.15 σ_y limit for the 10:90 blend (Fig. 5a). The specific total work of fracture, w_f, at this ligament length is nevertheless considered in the determination of the specific work of fracture for the material. All ten data points result in the best calculated figure for the correlation factor (R^2). This observation is a sign that the importance of the net-section stress condition is limited and that, yet again, the 1.15 σ_y limit does not appear to be required in the study of the EWF method for this particular blend.

Table 2 $2r_p$ values for PBT/PPT blends

	10:90	30:70	50:50	70:30	90:10
$2r_p$/mm	17.0±1.6	28.3±2.5	24.1±2.4	38.0±2.7	27.2±1.8

Table 3 T_g and crystallinity level data for each PBT/PPT blend

	T_g/°C (onset value)	ΔH_d/ J g^{-1}	ΔH^0/ J g^{-1}	Apparent level of crystallinity/%
90:10	47	22	145	15
70:30	45	10	145	7
50:50	46	13	145	9
30:70	47	2	145	0
10:90	51	1	145	0

Valid ligament length range

Plastic zone size ($2r_p$) values for each composition correspond to less than one third the width of the samples (Table 1). However, no real deviation from linearity is noticeable for the intermediate data and the highest limit (w/3=15 mm) has therefore been used.

PBT/PPT blends

Young's modulus

All values of E were higher than those determined for both pure components constituting the PBT/PPT blends (Fig. 6). In contrast to blends of PET/PPT, the higher figures obtained for E in this case are accompanied by high w_e values. The assumption that a high value of E denotes a highly crystalline but brittle material may not therefore be valid here. The fact that PBT exhibits a much lower Young's modulus than PET does, may be the reason for this unexpected behaviour. It is possible that the presence of PBT, a more flexible polyester, may have better dissipated the energy associated with fracture by plastic deformation. It is clear that the values of E follow the same pattern as w_e. However, although the Young's modulus for both series of blends is of the same order their essential work of fracture values differ markedly. It appears that the difference in stiffness of the two polyester blends does not have any effect on their respective fracture toughness values. Instead, the variation in the latter values may originate from other intrinsic properties such as the miscibility of the components, thermal characteristics etc., or a combination of these factors.

Yield stress

Figure 7 demonstrates that all σ_y values are intermediate between those of pure PBT and PPT; with an overall slight increase starting from the lower PBT σ_y value to the higher σ_y value of PPT, except for the 10% PPT composition. Once again, these σ_y values do not seem to be greatly affected by the blend composition.

In both blends the behaviour of σ_y with increasing PPT content does not appear to be correlated to the measured w_e.

Specific essential work of fracture

All blend compositions display higher w_e values than pure PPT itself (Fig. 8). The blend containing 90% PPT has a value approaching that of PPT. In other words, 10% PBT content only slightly increases the resistance to fracture of PPT. However, blends that consist of between 10 and 70% PPT produce considerably higher w_e values; an increase of up to 160% over that for pure PPT. Blending PPT with PBT seems to reduce the amount of crystallisation of both materials. This may be due to the effect of good miscibility between these polyesters. Overall, the resulting materials display better strength/flexibility characteristics and are less brittle.

Specific non-essential work of fracture

The corresponding values of βw_p for PBT/PPT blends are plotted *vs*. PPT content in Fig. 9. As the PBT content increases there is a trend towards increasing βw_p. This is expected because PBT is a more flexible material (lower E value) with a greater propensity to undergo plastic deformation.

Net-section stress condition

Four out of the five compositions considered show a range of σ_n values above the 1.15 σ_y limit (Fig. 10). As in the case of the PET/PPT materials, poorer correlation factors result when 'deviating' data are rejected. Again, this supports the contention that the net-section stress condition is not essential for the blends studied here, which is in agreement with the findings of other workers. Indeed, Wu and Mai [21] have demonstrated that σ_n values greater than 1.15 σ_y, in the case of LLDPE films, remain valid.

Valid ligament length range

All five PBT/PPT compositions display $2r_p$ values that are higher than w/3 (Table 2). Since w/3 constitutes the smaller quantity (15 mm) this has therefore been employed as the upper limit of the valid ligament length range.

DSC analysis

Table 3 demonstrates that blends containing high PBT content exhibit the highest apparent levels of crystallinity. It is known that PBT has a fast crystallisation rate and that it is difficult to obtain in an amorphous state. This is evidenced by the value of 27% observed for the apparent level of crystallinity of pure thin-film PBT samples despite rapid quenching subsequent to compression moulding [1]. However, in the case of the 10:90 and 30:70 PBT/PPT blends tested these are essentially 100% amorphous. Thus, blending PPT with up to 30% PBT inhibits the crystallisation of this polyester. It is interesting to relate these data to the fracture test results. The hypothesis suggesting that differences between w_e values for the five PBT/PPT blends can be explained by variations in the level of crystallinity is now disputed. For instance, the 100% amorphous 30:70 blend has a value of w_e corresponding to 63.65±2.69 kJ m^{-2}. However, a similar value (64.23±3.26 kJ m^{-2}) is observed in the case of the much more crystalline 90:10 blend. Furthermore, despite the fact that both the 10:90 and 30:70 PBT/PPT blends are also completely amorphous, these exhibit very different fracture toughness values (Fig. 8).

The miscibility of PBT/PPT blends is difficult to assess using DSC techniques because of the similarity in the T_g values of both components. Glass transition temperatures corresponding to 49 and 52°C for PBT and PPT, respectively (as thin-film samples prepared and analysed in the same manner as the present blends) have been recorded [1]. It is not possible to establish whether the single glass transition event corresponds to a miscible blend or whether it consists of two superimposed events using the DSC heating trace for each polyester blend. However, it is noticeable that the blend with the highest T_g (10:90 PBT/PPT) also displays the lowest fracture toughness (41.78±2.62 kJ m^{-2}). Bearing in mind that the mechanical tests have been carried out at room temperature, it is sensible to suggest that blends possessing the lowest glass transition temperatures would display the highest w_e values. In this situation, increased plastic deformation is observed, as seen in the corresponding specific non-essential work of fracture results (Fig. 9). On approaching the T_g of these materials greater flexibility is encountered, together with the simultaneous conservation of strength. Other workers have reported similar findings [11, 14, 16]. This may serve as an explanation for the substantial difference between the fracture toughness values of PBT/PPT and PET/PPT blends. Mixtures of PET and PPT, having higher glass transition temperatures, display lower w_e values because of the greater gap between their T_g values and the fracture testing temperature.

Conclusions

The fracture toughness of two different blends of polyester at different compositions has been studied using the essential work of fracture method. The specific essential work of fracture for mixtures of PET/PPT ranges from 27.33 to 37.38 kJ m^{-2}. In the case of PBT/PPT blends, the same determination results in values ranging from 41.78 to 64.23 kJ m^{-2}.

All tests were conducted under the state of pure plane stress as the conditions for net-section stress were almost invariably fulfilled. Those data that deviate from this condition have, however, been considered, with good reason, in the determination of the specific essential and non-essential works of fracture (the latter condition is not essential in the case of the materials studied).

Blending PPT with PET lowers the resistance to fracture of PPT. On the other hand, PPT shows improved fracture toughness when blended with PBT, denoted by the significantly higher w_e values obtained. DSC analysis indicates that the crystallinity level of the most promising PBT/PPT blends has no effect on their fracture toughness. Instead, differences between w_e values at each composition are explained by the slight variations in their T_g values. This explanation is suggested as the most plausible one, although other characteristics such as blend miscibility should be considered and would require further investigation.

Acknowledgements

The authors express their thanks to Dr. J. Candlin and Mr. T. Bonner from the University of Teesside and Dr. J. Carter from ICI, Wilton, Middlesbrough, UK for their advice, help and support. ICI Technology, Wilton and Huntsman Tioxide, Billingham are gratefully acknowledged for their assistance. Without the receipt of matched funds from the School of Science and Technology Research Fund, University of Teesside and Medtronic/AVE, Ireland Ltd. this work could not have been conducted. The authors also wish to thank Dupont Polyester, Bayer AG and Shell Chemicals Belgium S.A. for their kind donation of materials.

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DOI: 10.1007/s10973-006-7596-0