The Fine Structure of Bicomponent Polyester Fibers

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ABSTRACT: The application of alkaline hydrolysis to study the change in the fine structure of bicomponent polyester fibers as their surface is removed progressively was explored. The samples were prepared with a poly(butylene terephthalate) (PBT) sheath and a poly(ethylene terephthalate) (PET) core. The reagent used to hydrolyze the PBT was $1M$ NaOH in 75/25 methanol to water since it appeared to react topochemically with the fiber. The solution reacted more rapidly with PET than with PBT. Thus, when necessary to retard the weight loss of the bicomponent fibers, after a 2-h hydrolysis with this reagent to remove PBT, it was replaced with aqueous $1M$ NaOH solution containing 0.1% cetrimmonium bromide. Unlike homofil PET or PBT fibers, where alkaline attack appeared to be confined to the surface and left the residue relatively smooth, the bicomponent fiber was attacked unevenly, and penetration to the PET core occurred before all the PBT at the surface was removed. Nevertheless, most of the reaction was confined initially to the PBT sheath. The tenacity and extension at break of the PBT–PET fiber passed through a maximum as hydrolysis progressed. The fall in tenacity at high weight losses is ascribed to increasing surface defects in the fiber surface. After removal of the PBT by the hydrolysis, the birefringence of the residue became progressively higher. The synergistic effect of the PBT sheath on the properties of the PET core and the possible causes of the nonuniform hydrolysis at the PBT surface are discussed. An equation is proposed that includes an interaction parameter, which can be utilized to determine which property is affected most by the hydrolysis of a bicomponent fiber. In this instance, it appears from the parameters that the order is strength > extension at break ≈ birefringence. © 1999 John Wiley & Sons, Inc. J Appl Polym Sci 71: 1163–1173, 1999

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INTRODUCTION

We have shown that the fine structure of polyester fibers can be studied by hydrolyzing such products with aqueous sodium hydroxide. The re-

action starts at the fibers' peripheries, causing weight loss but leaving the residues nondegraded, as indicated by molecular weight determinations.[1] The diameter of the residues can also be predicted from the weight losses.[1] After the hydrolysis, such parameters as tenacity, extensibility, birefringence, and density can be determined, thus establishing a profile of the fine structure of the fiber. Using this technique, we have studied the properties of poly(ethylene terephthalate) (PET) fibers of intrinsic viscosities (IV) of about
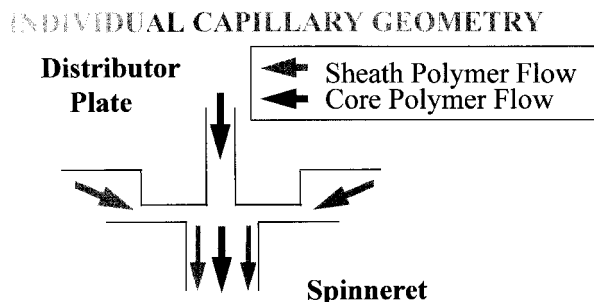

INDIVIDUAL CAPILLARY GEOMETRY

Figure 1 Schematic of the spinning equipment.

$0.6^{1,2}$ and 0.9^3 as well as a thermotropic liquid crystalline copolyester fiber.[4] Here, we explore application of this technique to sheath–core bicomponent fibers, in which the sheath is poly(butylene terephthalate) (PBT) and the core is PET, and to consider the effect on the physical properties of this material due to the presence of a PBT sheath on a PET core.

EXPERIMENTAL

Materials

The PBT–PET samples were spun on a machine specially designed for manufacturing sheath–core bicomponent fibers (Fig. 1). The PBT and PET polymers were melted in separate extruders and fed to a special spinning pack, which brought the two polymers together at the spinneret. Thus, the PBT polymer was kept cool until it met the PET stream immediately before exiting the pack as a filament. This minimized degradation of the PBT as the melt temperatures of the PET and PBT were 307 and 264°C, respectively. The IVs of the starting PET and PBT were 0.92 and 1.00,

respectively. Typically, the IV loss in spinning was about 0.04. The sheath level was 25% by weight. PBT and PET homofil samples were produced on the same spinning machine, with no distinction being made between the sheath and core polymers. The PBT–PET samples were drawn in a two-stage operation to overall draw ratios of 2.6 and 2.2. The final draw roll was heated to 210°C, and the yarn was allowed to relax 1.5% prior to winding up at 200 mpm. The spinning conditions and sample codes are given in Table I.

Procedures

Alkaline Hydrolysis

All hydrolyses were carried out in sealed flasks at 21°C (±2°) with mild mechanical agitation. The reaction solution varied depending on whether the yarn was composed of bicomponent filaments or homofils. The bicomponent samples were either hydrolyzed for progressively increasing lengths of time with $1M$ NaOH in 75/25 methanol to water or for 2 h with this reagent and subsequently for varying lengths of time with aqueous $1M$ NaOH containing 0.1% cetrimmonium bromide (CTAB). PBT homofil was hydrolyzed with $1.0M$ NaOH in 75/25 methanol to water for varying lengths of time. In all cases, the reaction termination, sample rinsing, and drying were as described previously.[1]

Tensile Testing

Not less than 20 determinations per sample were made on single filaments on an Instron Testing Machine using a 101.6-mm gauge length at a crosshead speed of 20 mm/min at 21°C and 65%

Table I Samples and Codes

Sample Description	Code	Spinning Speed (m/min)	Overall Draw Ratio	Filament Linear Density (dtex)
Undrawn PBT–PET	AU	1600		7.84
Drawn PBT–PET	AD	1600	2.6	3.29
Undrawn PBT–PET	BU	2000		7.18
Drawn PBT–PET	BD	2000	2.2	3.06
Undrawn PET	CU	1600		7.14
Drawn PET	CD	1600	2.6	2.90
Undrawn PBT	DU	1600		6.59
Drawn PBT	DD	1600	2.6	2.87

relative humidity (RH). The coefficient of variation of breaking forces, initial moduli, and extensions was about 10%. Breaking forces were divided by the dtex of the filaments to convert the force to tenacity, where dtex is the weight in grams of 10,000 meters of filament conditioned at 21°C and 65% RH. For the starting products, it was measured by weighing 1-m lengths of yarn and dividing by the number of filaments in the yarn. Ten determinations were made each time. The dtex of hydrolyzed products was calculated from that of the starting sample, and the weight loss suffered. Initial moduli were calculated from the slope of the beginning straight line portion of the force–extension curves.

Birefringence

Birefringence (Δn) was measured by the Becke line method. Fibers were immersed in liquids of known refractive index (R. P. Cargille Laboratories, Inc.) and viewed under a Zeiss polarizing light microscope. Adjacent sections of the same fiber were used to obtain the refractive indices parallel to ($n_{\parallel}$) and perpendicular to ($n_{\perp}$) the fiber axis, and Δn was then calculated as follows:

$$\Delta n = n_{\parallel} - n_{\perp}$$

The birefringence of ten fibers was determined each time. Readings agreed to 0.001. With the starting drawn bicomponent fibers (AD and BD), as well as AD and BD of low weight loss, a halo was observed at the fiber's edge, which made it difficult to make accurate determinations. Consequently, these birefringences are omitted from the tables.

Sheath Thickness

Drawn filament cross sections were cut by the Shirley plate method.[5] The width of the sheath and fiber diameter were measured on a light microscope with a calibrated eyepiece. Determinations were made on ten filaments each time. The coefficient of variation of the diameters was about 3% and of the sheaths, 10%.

Density

Measurements were made at 21°C (± 2°C) in a density gradient column prepared with aqueous calcium nitrate.[6] Samples were in the form of bundles of fibers tied into small knots, and the loose ends were cut off. In the case of the PBT homofil samples, densities were determined by a technique essentially similar to that described for the calibration of standard floats in ASTM D1505-85.[6]

Scanning Electron Microscopy

Samples were examined with an International Scientific Instruments model DS 130 microscope operating in the secondary mode at an accelerating voltage of 10 kV. The samples were mounted on standard specimen stubs with silver paint, and the stubs were then spattered with gold.

RESULTS AND DISCUSSION

Properties of Starting Products

The diameters of the drawn bicomponent filaments AD and BD were 18.1 μm and 17.6 μm, respectively, while the thicknesses of their sheaths were 1.61 μm and 1.62 μm, respectively.

As expected, drawing of the samples increased their tenacity and initial modulus and reduced their extension at break (Table II). Birefringence is a measure of the orientation of the polymer chains with respect to the fiber axis. With respect to the undrawn bicomponent fibers, BU was spun at a faster speed than AU, 2000 m/min versus 1600 m/min; and, as a result, the tenacity and birefringence of BU was higher than that of AU.

Bicomponent AU and undrawn homofils CU and DU were spun at the same speed. The PBT homofil DU had a slightly lower tenacity than the PET homofil CU, but its birefringence was markedly higher, 0.109 versus 0.022. In comparison, AU with its PBT sheath had a comparable tenacity to CU, but its birefringence was significantly higher, 0.038 versus 0.022. However, the birefringence of AU was much lower than that of DU. It appears then that the effect of the PET core of AU is to decrease the birefringence, or orientation, of its PBT sheath. It will be noted that birefringence determinations were being made at fiber peripheries.

After drawing, the tenacity and initial modulus of AD were similar to drawn PET homofil CD but AD had a lower extension at break than CD. Drawn PBT homofil DD had a markedly lower tenacity and initial modulus than either AD or CD, while its extension at break was higher.

The lower initial modulus of DD compared to CD can be attributed, at least in part, to its

Table II   Tensile Properties, Birefringence, and Density of Starting Samples

Code[a]	Tenacity (g/dtex)	Extension at Break (%)	Initial Modulus (g/dtex)	Birefringence	Density (g/cm³)
AU	2.26	170	19.8	0.038	
AD	6.93	9.27	92.5	[b]	1.386
BU	2.56	161	22.7	0.047	
BD	7.48	9.21	103	[b]	1.387
CU	2.27	190	19.4	0.022	
CD	6.67	15.4	98.6	0.183	1.408
DU	2.02	187	19.5	0.109	1.314
DD	5.41	25.8	25.5	0.156	1.335

[a] See Table I.
[b] Not measured.

lower birefringence. Also, PBT has twice as many methylene groups per repeat unit than PET, and this also will affect modulus markedly. Ward et al.[7] have associated the low modulus of PBT, as compared to PET, to the molecular conformation of PBT, never corresponding to the fully extended form so that deformation always involves bond angle rotations and bond bending rather than bond bending and stretching, as in the case of PET.

It appears that drawing does not increase the strength, initial modulus, and birefringence of DD, the homofil PBT sample, as much as the increases obtained with CD the homofil PET. In addition, it can be observed that the presence of a PET core permits the tenacity and initial modulus of bicomponent AD to be higher than that of DD and its extension at break to be lower.

Hydrolysis Conditions

From preliminary experiments, it appeared that the rate of hydrolysis of PBT products utilizing 2.5M NaOH and 0.1% CTAB at 21°C would be very slow. These are the conditions we have used in the past for other polyester products.[1–4] Consequently, we initiated use of 1.0M NaOH in 75/25 methanol to water at 21°C for the hydrolysis of PBT samples. When the drawn PBT homofil was hydrolyzed with this reagent, it was found that the weight loss increased linearly with time (Fig. 2). The R^2 value of the regression line was 0.990. Also, the tenacity of the hydrolyzed residues only decreased a small amount up to a weight loss of 37% (Table III). Thus, it appears, as in the case of the hydrolysis of PET with 2.5M NaOH and 0.1% CTAB[1–3] that the PBT is being

hydrolyzed at the periphery of the fiber and the residue has been little affected.

In the case of the bicomponent filaments, once some of the PBT sheath had been eliminated, the residue was rapidly consumed by the sodium hydroxide dissolved in aqueous methanol. Consequently, in some instances, after a 2-h treatment with 1.0M NaOH in methanol to water had resulted in about 14% weight reduction, the reagent was replaced with aqueous 1M NaOH and 0.1% CTAB. The weight loss then proceeded more slowly and, thus, could be better controlled. For similar weight losses, the physical properties of the bicomponent fibers did not appear to be affected by the method of hydrolysis.

As stated earlier, the sheath level was 25% by weight. The question of why the hydrolysis rate increased, after 14% weight loss, on continued treatment with the NaOH–CH₃OH–H₂O reagent is interesting. It has been reported that PBT and PET have good miscibility and can form a common amorphous mixed phase.[8,9] However, it is unlikely in our case that there was much blending at the interface since the contact time of the PBT and PET in the melt phase was only 1 to 2 s. Studying cross sections by light microscopy, it could be observed that the demarcation between the sheath and core was sharp. Thus, a common amorphous mixed phase would not explain the increasing hydrolysis rate observed.

To attempt to obtain an explanation for the unanticipated acceleration of the hydrolysis after low weight losses, PBT–PET samples were examined using a scanning electron microscope (SEM). The surfaces of the nonhydrolyzed AD and BD were smooth, as shown in a typical micrograph
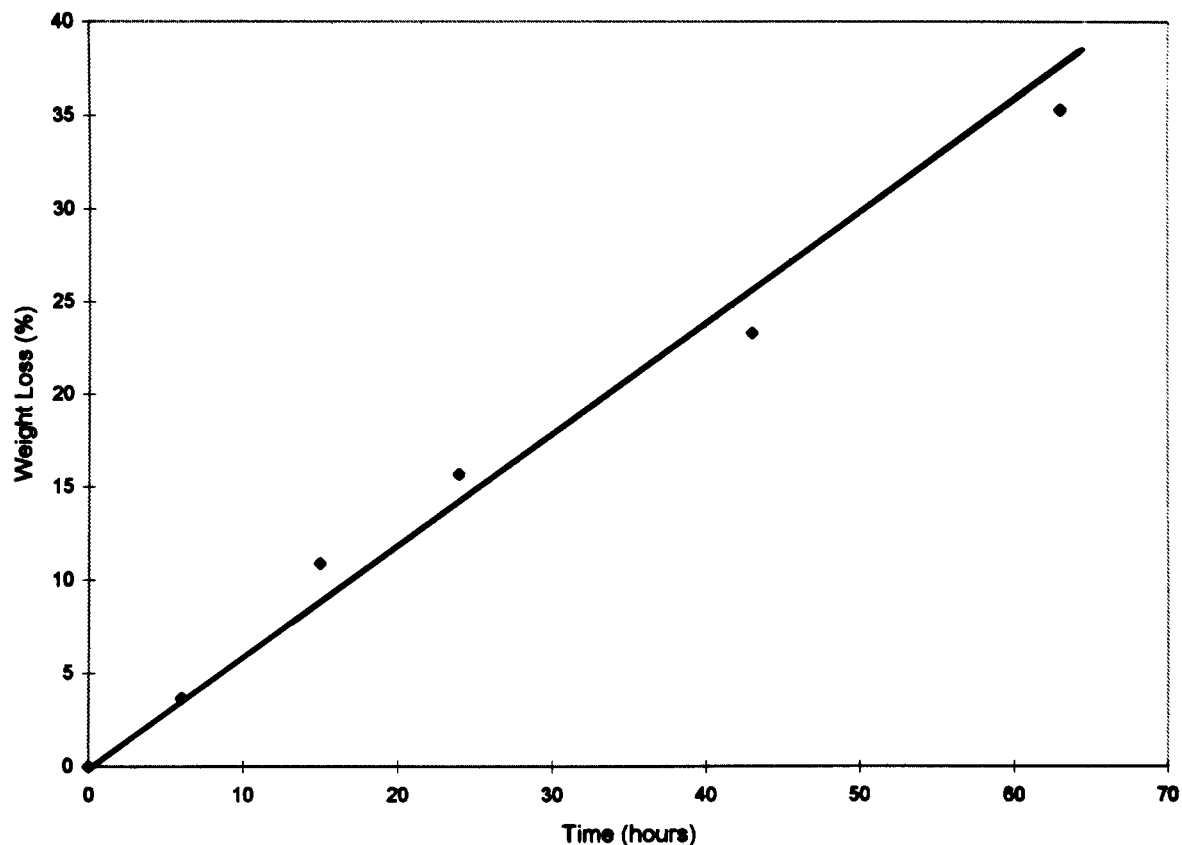
Figure 2   The weight loss–time relation of PBT homofil on hydrolysis with 1*M* NaOH in 75/25 methanol to water.

(Fig. 3). On hydrolysis, neither AD or BD eroded uniformly, as expected, at the fiber surface. It will be observed that the reaction is occurring preferentially in some regions, leaving the appearance of the fiber as a trunk threading a set of rings, which presumably consists of PBT (Figs. 4 and 5). This contrasts markedly with the hydrolysis of the drawn PBT homofil (DD) (Figs. 6 and 7), which has a roughened surface similar to that of PET hydrolyzed with methanolic sodium hydroxide.[10] As in the case of the nonhydrolyzed bicomponent fibers, DD had a smooth surface before hydrolysis (Fig. 8). It appears then that some regions of the PBT–PET bicomponent fibers are

Table III   Weight Loss and Tenacity of PBT Homofil (DD) Hydrolyzed with 1.0*M* NaOH in 75/25 Methanol to Water at 21°C for Increasing Lengths of Time

Hydrolysis Time (h)	Weight Loss (%)	dtex	Tenacity (g/dtex)	Relative Tenacity
—	—	2.87	5.41	1.00
6	3.68	2.76	5.33	0.99
15	10.9	2.56	5.26	0.97
24	15.7	2.42	5.05	0.93
43	23.3	2.20	5.04	0.93
63	35.3	1.86	5.06	0.94
80	36.6	1.82	4.95	0.91
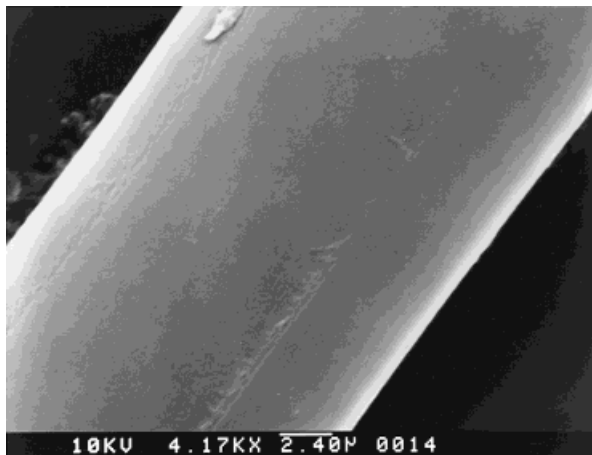
Figure 3 Scanning electron micrograph of nonhydrolyzed BD.

Figure 5 Scanning electron micrograph of hydrolyzed AD; weight loss = 14.4%.

more reactive to the NaOH–CH$_3$OH–H$_2$O reagent than other sections, and penetration to the PET occurs at roughly 14% weight loss, resulting in an accelerating reaction as the PET is attacked in these areas.

At a weight loss of 3.8%, some of the fiber's surfaces appeared porous (Fig. 9). Other sections already had the initiation of PBT rings (Fig. 10). At a weight loss of 36.8%, the rings had disappeared, but there still appeared to be PBT on some of the fibers (Figs. 11 and 12), although the density of these products is now similar to that of a drawn PET (compare the densities of hydrolyzed AD in Table IV and the density of CD in Table II). At this point, preferential attack of the PET is taking place, leaving a skin of PBT. The

surface of the fibers, when presumably only PET remains, can be observed in Figure 13, taken at a weight loss of 82.7%.

The ring structure observed in Figures 4 and 5 reflect the morphology produced in the formation of the fiber. The following speculation is offered as an explanation. In the bicomponent spinning process, the PET melt temperature was kept about 10° lower than normal. In normal spinning, this could give rise to melt fracture, namely, a slip stick phenomenon at the spinneret hole, which manifests itself in mild form as a sharkskin effect on the fiber surface. It also makes it difficult to take up the fibers. In the case of the bicomponent, the "slip stick" is covered by the PBT sheath and allows the fiber to apparently spin normally. In this regard, it was observed that the bicomponent
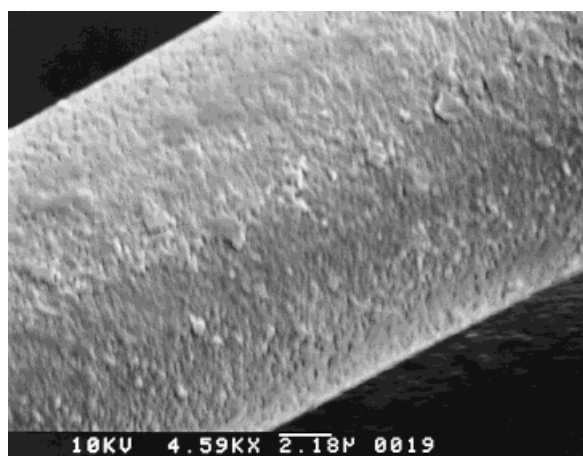

Figure 4 Scanning electron micrograph of hydrolyzed BD; weight loss = 14.6%.

Figure 6 Scanning electron micrograph of hydrolyzed DD; weight loss = 15.7%.

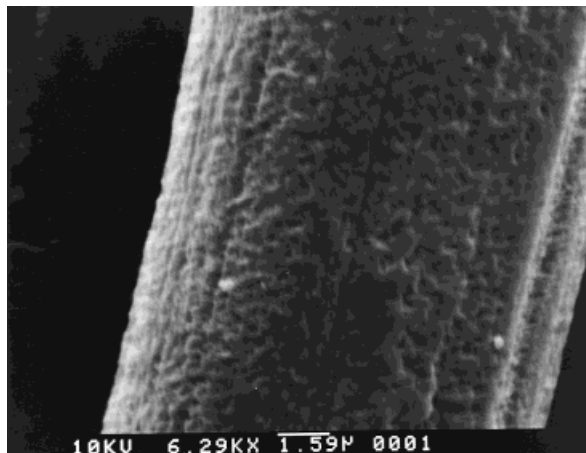**Figure 7** Scanning electron micrograph of hydrolyzed DD; weight loss = 38.5%.

Figure 9 Scanning electron micrograph of hydrolyzed AD; weight loss = 3.8%.

appeared to spin better than the PET alone. There were fewer filament breaks, as measured over long spinning periods. Thus, the melt fracture could create a crenelated PET core. As a consequence, the PBT sheath would have thick and thin regions. On hydrolysis with the methanolic NaOH solution, the PET core would be reached faster in areas where the PBT was thinner, and the resulting product would have the ringed morphology, we found.

Prior to the fiber formation, it was speculated that spinning at a lower than normal temperature for PET would significantly enhance the fiber properties of the bicomponent fiber compared to the homofil. While this did not happen, the bicomponent fiber was still comparable in tenacity with the PET (cf AD and CD, Table II). This indicates
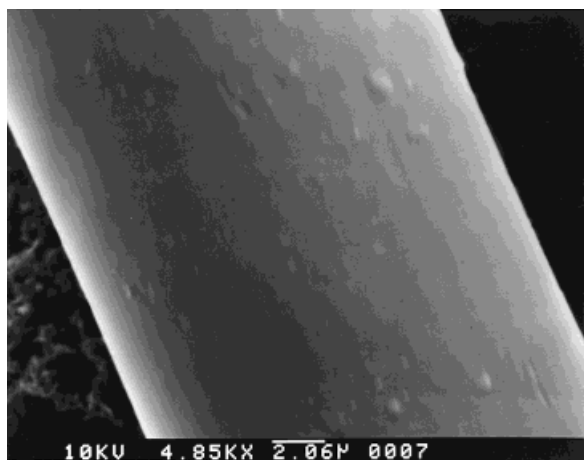
that even though the fiber might be defective in that the PBT–PET interface is nonuniform, it is still strong. If conditions could be found to decrease this nonuniformity, then the fiber strength could be improved. The hydrolysis procedure described in this article could be used to measure the degree of improvement made by process changes.

Tensile Properties and Birefringence of Drawn Bicomponent Fibers

As stated earlier, the birefringence of AD and BD, as well as AD and BD of low weight losses, could not be measured accurately. It will be observed that the birefringence of AD and BD appears to increase as the weight loss is pro-
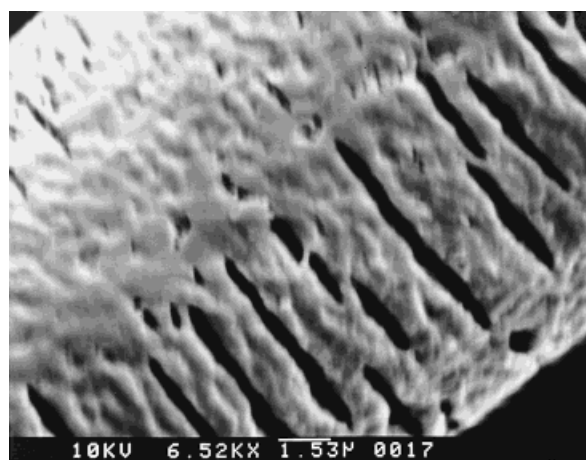

Figure 8 Scanning electron micrograph of nonhydrolyzed DD.

Figure 10 Scanning electron micrograph of hydrolyzed AD; weight loss = 3.8%.
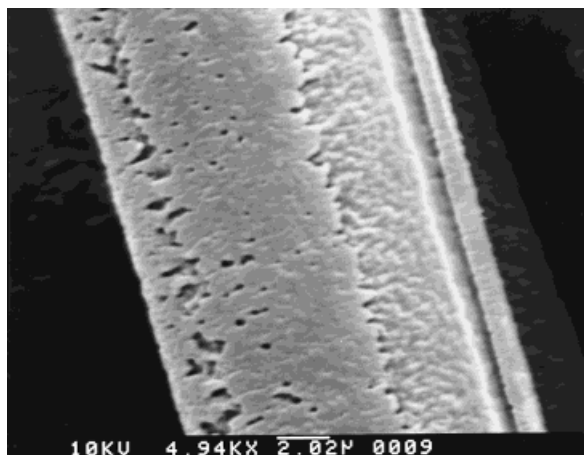
Figure 11 Scanning electron micrograph of hydrolyzed AD; weight loss = 36.8%.
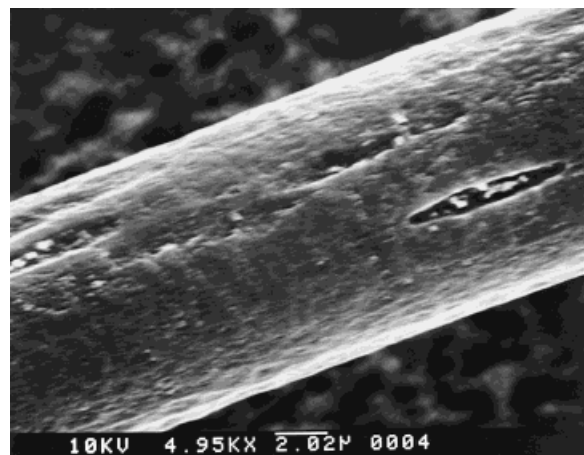

Figure 13 Scanning electron micrograph of hydrolyzed AD; weight loss = 82.7%.

gressively increased from 11 to 83%. At the highest weight losses, the birefringence is similar to that of the drawn PET homofil CD (compare Tables II and IV).

The tenacity of both AD and BD passed through a maximum with increasing weight loss (Table V). This contrasts with the tenacity of homofil PET, which does not increase on loss in weight induced by alkaline hydrolysis. Instead, the tenacity of homofil PET will either remain constant or decrease slightly until the weight loss becomes large.[1–3] Thus, removal of the PBT sheath results in a high tenacity PET core fiber. The sheath does not appear to have affected the breaking extension as markedly. Again, comparisons can be made between AD

Figure 12 Scanning electron micrograph of hydrolyzed AD; weight loss = 36.8%.

and CD. Here, it will be noted the starting AD and CD have similar tenacities. By a weight loss of 30%, AD had a markedly higher tenacity than CD (8.5 versus 6.7 g/tex). The fall in strength at high weight losses of AD may be due to increasing numbers of surface defects at which rupture is initiated. In previous work,[1] it was shown that the DP of PET fiber subjected to aqueous alkaline hydrolysis remained constant, but its strength began to fall sharply after the weight loss increased above roughly 30%. It was hypothesized that the fall in strength was due to increased weak points or defects at the surface. It is important to note, however, that in the present case when the PBT sheath appears to have a synergistic effect on the PET core, the loss in strength of the AD core is relatively small compared to CD, with the PET homofil spun under identical conditions. It is 13% at a weight loss of 82.7%. In contrast, in the earlier study[1] with a semidull and bright PET, the loss in strength of the former at a weight loss of 68% was 42%; and in the latter case, the strength loss was 38% at 80% weight loss.

The initial modulus of AD also increased on hydrolysis at higher weight losses and became similar to that of CD (compare Tables II and V). Thus, the presence of the PBT sheath appeared to lower the overall initial modulus of the fiber; after its removal, the modulus of the residue reverted to that of PET. It appears from the data that the initial presence of a PBT sheath had resulted in a PET core with enhanced strength.

While attention has been focused on AD since it was spun under the same conditions as CD and
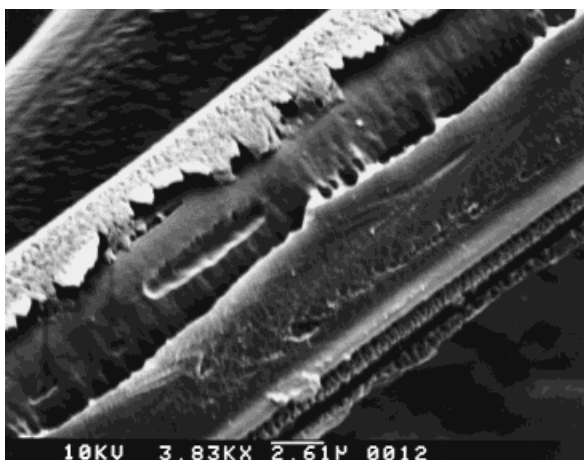
Table IV   Birefringence (Δn) and Density of Drawn Bicomponent Filaments After Hydrolysis

Sample[a]	Weight Loss (%)	$n_\parallel$	$n_\perp$	Δn	Density (g/cm^3)
AD	—			[b]	1.386
	0.60			[b]	
	3.8			[b]	
	11.2	1.723	1.544	0.179	
	14.4	1.723	1.544	0.179	
	29.6	1.725	1.540	0.185	1.400
	31.7	1.717	1.540	0.177	1.400
	36.8	1.728	1.540	0.188	
	82.7	1.724	1.541	0.183	1.400
BD	—			[b]	
	0.77			[b]	
	14.3	1.725	1.542	0.183	
	14.6	1.730	1.542	0.188	
	28.8	1.725	1.540	0.185	
	32.9	1.726	1.540	0.186	
	41.0	1.728	1.539	0.189	
	71.1	1.725	1.541	0.184	

[a] Code given in Table I.
[b] Not measured.

DD, it will be noted that the change in properties of BD is similar to AD on hydrolysis (Tables IV and V).

Table V   Tensile Properties of Drawn Bicomponent Filaments After Hydrolysis

Sample[a]	Weight Loss (%)	Tenacity (g/dtex)	Extension at Break (%)	Initial Modulus (g/dtex)
AD	—	6.93	9.27	92.5
	0.6	7.06	9.37	83.3
	3.8	7.18	9.16	81.3
	11.2	6.54	9.28	75.8
	14.4	7.01	9.99	94.6
	22.6	7.19	8.26	87.2
	25.0	7.69	9.33	98.3
	29.6	8.51	10.33	97.4
	31.7	7.90	9.80	104
	82.7	5.78	6.66	112
BD	—	7.48	9.21	103
	14.6	7.85	9.85	—
	22.1	8.11	8.26	92.2
	28.8	8.76	9.35	—
	30.5	8.60	8.58	104
	31.4	7.72	8.87	108
	32.9	9.22	9.23	—
	71.1	6.59	7.28	106

[a] Code given in Table I.

Analysis of the Properties as a Blended System

Many properties of a material system blended with two or more different components can be calculated directly by using the simple Rule of Mixtures (ROM) when there is no interaction existed between the components.[11] So, for a two-constituent system, the overall system property X_s can be found as

$$X_s = X_1 V_1 + X_2 V_2 \qquad (1)$$

where X_i and V_i are the corresponding property, and the volume fraction of component $i = 1$ and 2.

From this relationship, it can be seen that if there is no interaction, the overall system property X_s cannot be either greater or smaller than the property value X_i of either component. Therefore, equation (1) can be used as a criterion to examine any possible interactions between the two constituents in a blended system. A plot of X_s against V_1 results in a straight line. Thus, if the experimental results of the system property fall exactly on the line, it can be inferred that there are no interactions at all. If interactions indeed exist and cause a reduction in system property, then the data will fall below the line. On the other hand, an increase (a synergy) in system property will result in the experimental data occurring above the line.
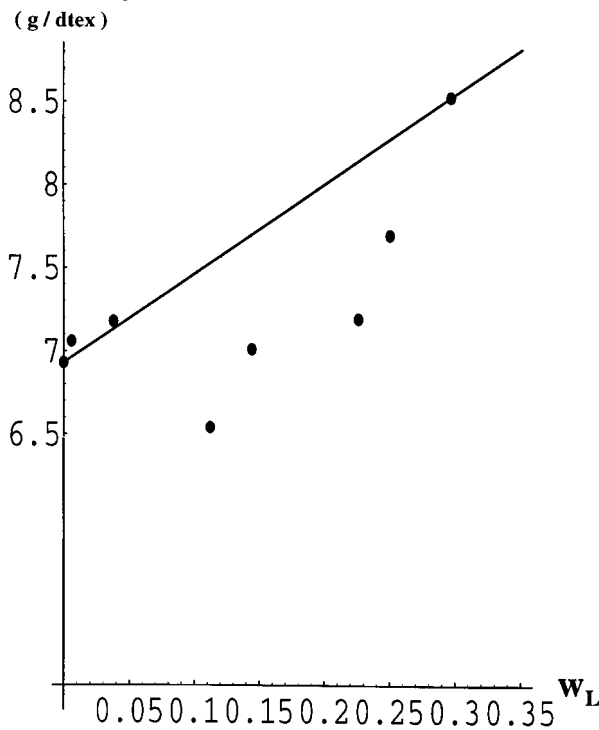
Tenacity

(g / dtex)

Figure 14   Plot of strength versus weight loss of AD using eq. (3).

Furthermore, a modified Rule of Mixtures can be adopted to deal with the cases in which interactions exist,[12] as follows:

$$X_s = X_1 V_1 + X_2 V_2 + \Delta X \qquad (2)$$

where ΔX is used to account for the effect on system property caused by the interactions. If $\Delta X > 0$, the interactions result in a positive or a synergetic effect, and $\Delta X < 0$, a negative or reduced effect.

Turning to the data in this article, it will be noted that it was accumulated in terms of weight loss and not volume fractions of the system after hydrolysis. This renders a problem in analysis in that it is difficult to convert the weight loss into the volume fraction required in eq. (2) since it is extremely tedious to precisely determine the relative proportions and the distributions of the two components in the system at each level of hydrolysis. The irregular pattern of the dissolution process, as discussed before, further complicates the issue also.

As an alternative, we propose another empirical model to investigate the relationship between

the system and component properties as a function of the weight loss, as follows:

$$X_s = X_{so} + a(W_L - W_{Lo})X_1 \qquad (3)$$

where X_{so} is the original system property before the hydrolysis treatment, and a is an interaction coefficient. X_{so} can be calculated from eq. (2) if all the required information is given, or is known experimentally, as shown in Tables II, IV, and V. W_L is the weight loss and W_{Lo} is the starting point when data was collected. For instance, for the birefringence data in Table IV, W_{Lo} equals 11.2%, and for the cases taken from Table V, W_{Lo} equals 0%. Also, X_1 is the original property of the core component (PET) when it is alone (CD). The interaction coefficient a to be determined experimentally reflects the difference between various system properties. The larger the value of a, the greater the effect of the hydrolysis.

As the hydrolysis proceeds and the weight loss W_L increases, the weaker, more flexible, and more extensible component (PBT) is first to dissolve away, and the contribution of the reinforcing component (PET) becomes increasingly significant, leading to an increase of system property repre-
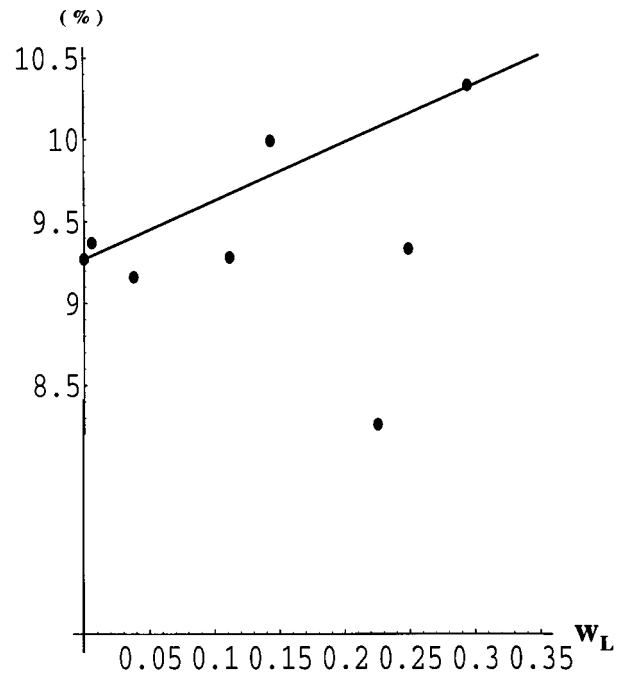
Extension at break

(%)

Figure 15   Plot of extension at break versus weight loss of AD using eq. (3).
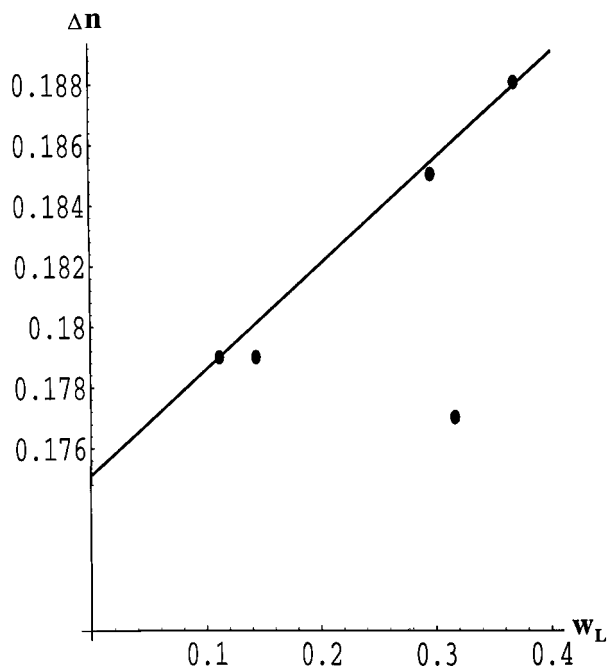
Figure 16 Plot of birefringence versus weight loss of AD using eq. (3).

sented by the term $(W_L - W_{Lo})X_1$. Equation (3) may thus provide an explanation for the synergy in system properties. It is more applicable when the reaction occurs primarily with the PBT, that is, roughly the first 40% of the hydrolysis.

Figures 14–16 are drawn with regression lines according to eq. (3) for tenacity, extension at break, and birefringence using the data in Tables IV and V. The values obtained for coefficient a of the tenacity, extension at break, and birefringence are 0.8, 0.23, and 0.19, respectively. Thus, this coefficient can be used to predict that the impact of the hydrolysis on properties is tenacity > extension at break ≈ birefringence.

CONCLUSIONS

Alkaline hydrolysis can be used to study the fine structure of PBT–PET sheath–core bicomponent fibers, although the hydrolysis does not progress topochemically, as in the case of homofil PET and PBT fibers. The birefringence, tenacity, breaking extension, and modulus of the bicomponent fiber increase after removal of its sheath. It appears that when the PBT sheath of a drawn PBT–PET bicomponent fiber is removed, the remaining PET fiber has enhanced tenacity when compared to a homofil PET spun and drawn in the same manner. An equation is proposed that includes an interaction parameter, which can be utilized to quantize which property is affected the most by the hydrolysis of a bicomponent system. In this instance, the order is strength > extension at break ≈ birefringence. The alkaline hydrolysis appears to have revealed a structural nonuniformity that can be traced back to fiber formation. Thus, it has potential as a tool in assisting the development of improved bicomponent fibers.

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