Effect of the Components' Molar Mass and of the Mixing Conditions on the Compatibilization of PE–LCP Blends by PE-g-LCP Copolymers

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ABSTRACT: The rheology, morphology, and mechanical properties of blends of highdensity polyethylene (HDPE) with a semiflexible liquid crystalline copolyester (SBH) were studied in order to assess the compatibilizing ability of added PE-g-SBH copolymers, and its dependence on the molar mass of the PE matrix, and on the technique used for blend preparation. The PE-g-SBH copolymers were synthesized as described in previous articles, either by the polycondensation of the SBH monomers in the presence of a functionalized PE sample containing free carboxyl groups, or by reactive blending of the latter polymer with preformed SBH. Two samples of HDPE having different molar masses, and two samples of SBH with different melt viscosity and different microstructure, were used for preparing the blends. The two components and the compatibilizer were either blended in a single batch or used to prepare binary master blends to which the third component was added at a later stage. The results indicate that the PE-g-SBH copolymers do, in fact, compatibilize the PE-SBH blends and that the effect is more pronounced with the lower molar mass PE matrix and with the SBH sample having lower viscosity. The experiments carried out on blends prepared with different techniques show that the compatibilizing ability of the graft copolymer is improved if the latter is first blended with either of the two main components. © 1999 John Wiley & Sons, Inc. J Appl Polym Sci 71: 603-613, 1999

Key words: polyethylene-LCP blends; compatibilization; morphology; rheology

INTRODUCTION

Adding a small amount of a liquid crystalline polymer (LCP) into, for example, polyethylene (PE) or polypropylene (PP), during processing

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might lead to a strong reinforcement of these polyolefins, provided the inherently poor interfacial adhesion of the two phases could be enhanced by the use of appropriate compatibilizers. In recent years, different commercial functionalized polymers, such as maleic-anhydride-grafted PP (PP-g-MA),¹⁻⁵ or acrylic-acid-grafted PP (PP-g-AA),⁶⁻⁸ have been tested as compatibilizing agents for the PP–LCP blends. The slight improvement of adhesion between the PP matrix and the dispersed LCP particles caused by these functionalized PP samples have been attributed to the promotion of specific polar interactions be-

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tween the blend components rather than the formation of true covalent bonds tying the two phases to one another. Similar results were found by some of us⁹ for blends of PE with a semiflexible LCP, compatibilized with maleic-anhydridegrafted PE. Also in this case, the slight increase of melt viscosity and the improvement of some of the mechanical characteristics was attributed to hydrogen bonding.

It is believed that among compatibilizing agents, block or graft copolymers consisting of segments whose chemical structures are identical to those of the polymers being blended are best suited to the scope. The compatibilization mechanism is thought to involve the migration of the copolymer toward the interphase and the penetration of the two types of copolymer segments into the chemically alike phases. Thus, the copolymer is expected to lower the interfacial tension and to increase the adhesion between the two phases. This should stabilize the blend morphology, besides improving quite significantly its properties.

In a previous article,¹⁰ it was shown that *ad* hoc synthesized PE-g-LCP copolymers, obtained either by polymerizing the LCP monomers in the presence of a low molar mass functionalized PE.¹¹ or by blending the latter polymer with the LCP copolyester in the presence of a transesterification catalyst,¹² do, in fact, enhance the interfacial adhesion of PE-LCP blends, both in the melt and in the solid state. The compatibilizing effect of these copolymers was shown to manifest itself, not only by a significant improvement of the PE/ LCP blends morphology, but also by a slight increase of their melt viscosity and of their elongation at break.¹⁰ The enhancement of the mechanical properties was still modest, however, and this was interpreted considering that the molar mass of the functionalized PE used for the compatibilizers synthesis was fairly low ($\sim 10,000$ g $kmol^{-1}$), and this probably resulted in PE-g-LCP copolymers containing PE segments that are too short. The observed compatibilization effects were assumed to consist mainly of the modification of the surface characteristics of the LCP minor phase, while the penetration of the PE segments into the high molar mass PE matrix was thought to be poor.

It is well known that the molar mass of the matrix influences the morphology and the rheological behavior of a polymer blend because the latter characteristics vary with the two components' viscosity ratio. It is reasonable to expect, therefore, that the matrix molar mass also has an effect on the way the blend reacts to the addition of a given block or graft copolymer and that the best compatibilization is obtained for an appropriate match of the lengths of the homopolymer segments of the compatibilizer and the molar masses of the two phases. On the other hand, it is also likely that preblending the compatibilizer with one of the components may help the penetration of the copolymer segments whose length match is less favorable.^{1,2,13}

In this work, blends of two grades of PE and two grades of a semiflexible LCP (SBH 1 : 1 : 2, by Eniricerche S.p.A., Milan) were compatibilized with PE-g-SBH copolymers.^{11,12} The effect of the molar mass of the polymers on the compatibilizers efficiency was evaluated by rheological, morphological, and mechanical characterization of the blends. Moreover, the effect of preparing the compatibilized blends with different procedures was also investigated.

EXPERIMENTAL

Materials

The main characteristics of the materials used in this work are reported in Table I. The HDPE samples are two injection molding grades, namely, A1100 and UG6305, kindly provided by Solvay, Italy, and Polimeri Europa, Italy, respectively. The LCPs are semiflexible copolyesters (SBH 1: 1: 2) synthesized by the melt polycondensation of sebacic acid (S), 4,4'-diacetoxybiphenyl (B), and 4-acetoxybenzoic acid (H), in the mole ratio of 1:1:2. The synthesis and the characterization of these LC copolyesters have been described elsewhere.^{14–19} The samples used in this work were kindly supplied by Eniricerche S.p.A., Italy. The inherent viscosity, measured in pentafluorophenol at 60°C, with a concentration of $0.1~g~d\dot{L^{-1}},$ was 1.00 $d\dot{L}~g^{-1}$ for the first sample, coded H-SBH, and 0.87 dL g^{-1} for the second, coded L-SBH.

COPM and COPR are PE-grafted SBH (PE-g-SBH) copolymers. The first sample was prepared by the reactive blending of oxidized PE (PEox, Aldrich) and SBH (50/50 w/w), carried out in a Brabender mixer at 240° C and 100 rpm for 120 min in the presence of Ti(OBu)₄ catalyst, under a nitrogen blanket.¹² The second sample was synthesized by the melt polycondensation of a mixture of the SBH monomers, carried out in the presence of PEox and sodium acetate catalyst.¹¹

Material	Manufacturer	$MFI \ (dg min^{-1})$		Sample Code
A1100	Solvay	11	_	L-PE
UG6013	Polimeri Europa	3	_	H-PE
SBH	Eniricerche	_	1.00	H-SBH
SBH	Eniricerche	_	0.87	L-SBH
PE-g-SBH copolymer				
(polycondensation)	Magagnini et al. ¹¹	_	_	COPR
PE-g-SBH copolymer				
(reactive blending)	Minkova et al. ¹²	_		COPM

 Table I
 Main Characteristics of the Pure Samples

The nominal compositions of the two products are identical. Further details on the synthesis and the characterization of these copolymers have been reported elsewhere.^{10-12,20-22}

Blends Preparation

The blends were prepared in a Brabender internal mixer attached to a Brabender Plasticorder PLE 330. The mixing temperature was 240°C, and the rotational speed 30 rpm. The adopted mixing time (about 5 min) was enough to reach the asymptotic torque value.

Four different preparation procedures were used depending on the order of addition of the components into the mixing bowl. Details of the adopted addition techniques are shown in Table II.

The composition of the blends (80% PE and 20% SBH w/w, for the uncompatibilized blends, and 77.5% PE, 5% COP, and 17.5% SBH w/w/w, for the compatibilized ones) was calculated in order to have the same total amount (20% w/w) of SBH, including that contained in the PE-g-SBH copolymer. All the materials, except the two PE samples, were dried in a vacuum oven to prevent hydrolytic chain scissions during processing.

Rheological Characterization

The viscosity curves of pure polymers and blends were determined using a Rheometrics mod. RDAII viscometer in the parallel plate mode. The testing temperature was 240°C.

Morphology Characterization

The morphology of the blends was studied by scanning electron microscopy (SEM) using either a Philips mod. 501, or a Jeol T-300, apparatus. The samples were fractured in liquid nitrogen and coated with gold with a SPI sputter coater before observation.

Mechanical Characterization

Young's modulus (E), tensile stress (TS), and elongation at break (EB) of all the investigated materials were measured using an Instron mod. 1122 apparatus with a crosshead speed of 50 mm min⁻¹.

The samples were cut out of compression molded sheets prepared in a Carver laboratory press at 240°C. The gauge length was 30 mm, the thickness was about 1 mm, and the width was 5 mm. The results of at least seven measurements were averaged.

Table IIMixing Procedures for thePreparation of the Compatibilized Blends

Procedure	Description
А	One-step preparation: PE, SBH,
	and COP were dry-blended
	mixing bowl
В	First step: preparation of the
	binary PE–SBH blend.
	Second step: COP was mixed
	with the binary blend.
С	First step: preparation of the
	binary PE–COP blend.
	Second step: SBH was mixed
	with the binary blend.
D	First step: preparation of the
	binary SBH–COP blend.
	Second step: PE was mixed
	with the binary blend.



Figure 1 Viscosity curves of the pure components.

RESULTS AND DISCUSSION

Rheological Properties

The rheological behavior of the blends components is illustrated by the viscosity curves shown in Figure 1. It is interesting that the viscosity of COPM is 1-2 orders of magnitude higher than that of L-SBH, though being produced by reactive blending of the latter polymer with a very low molar mass (~ $10,000 \text{ g kmol}^{-1}$) functionalized PE.¹² This is evidence that reactive blending was, in fact, successful and resulted in SBH grafting onto the PE chains. It can also be observed that this copolymer shows fairly strong shear-thinning behavior. The viscosity curve of COPR is qualitatively similar, although its slope is somewhat lower. The absence of a Newtonian behavior for both COPM and COPR, and the increasing trend of their viscosity at low shear rates, was attributed to a kind of structured morphology of the molten state of these biphasic materials, which is other evidence in favor of grafting.¹⁰ On the other hand, the difference between the viscosity curves of COPM and COPR may be due to structural differences of the two copolymers, with respect to the distribution and the relative lengths of the SBH branches. 22

Of the two LCPs used in this work, L-SBH displays, expectedly, lower viscosity. However, from the values of the inherent viscosity mea-

sured in pentafluorophenol for these two LCPs $(0.87 \text{ dL g}^{-1} \text{ for L-SBH}, \text{ and } 1.00 \text{ dL g}^{-1} \text{ for H-}$ SBH), one would not expect their melt viscosities to differ so much, nor would one predict for the higher viscosity polymer (H-SBH) a yield behavior similar to that of the two copolymers described above. Apparent discordance among the characteristics of expectedly equal SBH samples produced in different batches had already been noticed in previous studies. However, it has been $shown^{23,24}$ that during the melt polycondensation of mixtures of aliphatic and aromatic monomers, when the length of the oligomer chains and, consequently, their mesogenicity increase, a liquid crystalline phase may segregate from the isotropic liquid, so that the reaction proceeds within two immiscible phases. Subsequently, depending on the mixture composition, the system may either become again homogeneous and lead to a random copolyester with the most probable composition distribution, or remain heterogeneous up to the end of the polymerization. In the latter case, the product will have bimodal composition distribution and biphasic morphology. For the particular case of the synthesis of SBH 1:1:2, it was found²⁴ that the microstructure of the copolyester depends in a critical way on the polymerization conditions; therefore, two expectedly identical products may have fairly different sequence distribution and, thereby, different rheological



Figure 2 Viscosity curves of the 80/20 L-PE–H-SBH and H-PE–H-SBH blends without and with 5% COPM.

properties. On the basis of this, the viscosity curves of L-SBH and H-SBH shown in Figure 1 may be interpreted assuming that the latter polymer, besides possessing higher molar mass, probably has a less homogeneous microstructure.

The viscosity of L-PE and H-PE is lower than that of H-SBH and the two COPs, at low shear rates. However, because the shear thinning behavior of these two PE samples is much less pronounced, their viscosity exceeds that of all other polymers at high shear rates.

The effect of adding H-SBH into either PE sample, with and without addition of 5% (w/w) COPM compatibilizer, is illustrated in Figure 2. A comparison of the viscosity curves of the blends with those of pure L-PE and H-PE shown in Figure 1 reveals that the addition of the LCP brings about a slight reduction of viscosity and, for the higher molar mass PE sample, a fairly strong non-Newtonian behavior at low shear rates. On account of previous information²⁵ on the widely accepted processing-aid effect of LCPs, the smallness of the viscosity reduction undergone in this case by the PE samples when added with H-SBH may appear surprising. It should be considered, however, that the present tests have been carried out in a rotatory viscometer, where no LCP fibrillation is expected to occur.

Concerning the compatibilized PE-H-SBH blends, it is clearly seen that the presence of

COPM has a fairly small effect on the H-PE blend, consisting of a slight increase of the shear thinning behavior, whereas it causes a significant increase of viscosity of the L-PE-H-SBH blend in the whole shear rate range. It is interesting that the increase of viscosity is also observed in the higher shear rate range, where the viscosity of COPM is lower than that of both pure L-PE and the L-PE-H-SBH blend, thus showing that the copolymer does, in fact, enhance the adhesion between the two phases of the blend in the molten state. The effect is stronger with the lower molar mass PE matrix. It may be worth mentioning, however, that the viscosity increase due to the compatibilizer is more pronounced at low shear rates. Here, a modest effect is observed also for the blend with H-PE.

The effect of the molar mass of the LCP dispersed phase was investigated by comparing the rheological behavior of the L-PE-L-SBH and L-PE-H-SBH blends, with and without compatibilizer (COPM, 5% w/w). The results are plotted in Figure 3. The first interesting observation is that the viscosity curves of the two uncompatibilized blends are almost undistinguishable, although the viscosity of L-SBH is appreciably lower than that of H-SBH, especially at low shear rates. This might be interpreted assuming that in the molten state, L-PE is more compatible with L-SBH than with H-SBH. Although the molar mass of the



Figure 3 Viscosity curves of the 80/20 L-PE–L-SBH and L-PE–H-SBH blends without and with 5% COPM.

former LCP is probably responsible for a better viscosity match with the L-PE matrix, it seems reasonable to assume that the L-SBH microstructure, too, contrary to that of H-SBH, has a favorable effect. The addition of the compatibilizer causes an increase of viscosity for both blends, particularly in the low shear rate range. Also, this effect is more pronounced for the blend containing L-SBH. Again, the molar mass of this LCP, as well as its microstructure, may be thought to provide better match with the same characteristics of the SBH branches of COPM.

The results show that the effect of the compatibilizer depends critically on the molar mass, and, for the case of SBH, on the microstructure, too, of the two blend components, as well as on the structure of the compatibilizer. Apparently, all these features influence the degree of penetration of the different segments of the graft copolymer into the alike phases.

In Figure 4, the effect of changing the mixing procedure is illustrated for the case of the L-PE– H-SBH blends, compatibilized with 5% (w/w) COPR. The compatibilizing effect of the latter copolymer is apparently similar to that of COPM. The low shear rate viscosity of the L-PE–COPR– H-SBH blend (Fig. 4) is only slightly lower than that of the corresponding blend containing COPM (Fig. 3), and this can be readily explained on the basis of the much higher viscosity of the latter copolymer in this shear rate range (compare with Fig. 1). The rheological behavior of the blend prepared by adding the compatibilizer to the preformed L-PE-H-SBH binary blend (compare with route B, Table II) is similar to that of the blend obtained from the three components mixed together (route A), except at low shear rates, where the viscosity tends to increase more steeply. An even stronger effect is observed for the blend prepared by route C, that is, by adding H-SBH to the master blend of L-PE and COPR. This blend displays the strongest shear thinning behavior. The reverse order of components addition (route D) leads to a blend having the smallest shear thinning; its viscosity is, in fact, very close to that of the normal blend (route A) at low shear but becomes highest at high shear rates. Although the effects described before are rather modest, they were found to show appreciable reproducibility, and the same trend was found when COPM was used as the compatibilizer.

The results described here confirm that the compatibilizing activity of the COP graft copolymers depends in a critical way on a number of factors, including the relative chain lengths of the two polymers being blended, the structure of the graft copolymers and the length of their homopolymer segments, and the microstructure of the LC copolyester chains. The positive effects of all these features may be emphasized further by



Figure 4 Viscosity curves of the 80/20 L-PE–H-SBH binary blend and of the ternary L-PE–COPR–H-SBH blends prepared according to different procedures.

choosing the most appropriate blending procedure.

Morphology

Although the morphology of the binary PE-SBH blends is that expected for highly incompatible polymers, with the globular droplets of the minor LCP phase displaying smooth surface and practically no adhesion to the matrix [Figs. 5(a,b) and 6(a)], their phase dispersion is nevertheless dependent of the nature of the components. In fact, the average dimension of the SBH particles is in the range of 1–10 μ m for the L-PE–L-SBH blend [Fig. 5(b)], which is clearly characterized by the optimum viscosity ratio, whereas larger droplets $(2-40 \ \mu m)$ are seen in the H-PE-H-SBH [Fig. 5(a)] and in the L-PE-H-SBH [Fig. 6(a)] blends. This confirms the importance of an appropriate match of the two components viscosity, although it may be pointed out once again that the possibility of a concomitant effect of the microstructure of the LCP must also be taken into consideration.

The addition of 5% w/w PE-g-SBH copolymer means an appreciable improvement of interphase adhesion [Figs. 5(c) and 6(b,c)]. Indeed, the SBH particles are tightly matrix-bound in the ternary blends, and their surfaces show signs of fraying and fibrils unraveling caused by the fracture. Moreover, a better dispersion of the SBH droplets can be generally observed for the compatibilized blends. A comparison of the micrographs of the different blends, however, shows clearly that the reduction of the SBH droplets dimensions is stronger for the L-PE-L-SBH [Fig. 5(c)] than for the L-PE-H-SBH blend [Fig. 6(b,c)], thus confirming that the PE-g-SBH copolymers display stronger compatibilizing effect for the blend of the lower viscosity components L-PE and L-SBH. As already stated, this may be due to the better match of the chain lengths of the different components, as well as to the more favorable microstructure of L-SBH.

Concerning the morphology of the compatibilized L-PE-H-SBH blends prepared with different mixing procedures, the micrographs shown in Figure 6(b,c) demonstrate that both the dispersion and the adhesion obtained with procedure D are much better than those found with procedure B. The micrograph of the blend prepared by route C (not shown) is similar to that shown in Figure 6(c). This is further evidence confirming the conclusion drawn from the results of the rheological measurements described above.

Mechanical Properties

The mechanical characteristics of compression molded samples of the pure components are shown in Table III. The different properties of



Figure 5 SEM micrographs of (a) uncompatibilized H-PE-H-SBH blend, (b) uncompatibilized L-PE-L-SBH blend, and (c) L-PE-L-SBH blend compatibilized with 5% COPM (mixing route D).

H-PE and L-PE may probably be due to the higher degree of crystallinity of the latter polymer. As for the LCPs, it may be observed that the mechanical properties of these semiflexible copolyesters, in the unoriented state, are fairly low. It has already been shown,¹⁸ however, that when

these LCPs are processed under conditions granting strong orientation, the mechanical characteristics are noticeably improved. Finally, the two PE-g-SBH copolymers behave as fragile materials, probably due to their biphasic nature; their modulus and their tenacity are intermediate between those of PE and SBH.



Figure 6 SEM micrographs of (a) uncompatibilized L-PE-H-SBH blend, (b) L-PE-H-SBH blend compatibilized with 5% COPR (mixing route B), and (c) the same blend prepared by mixing route D.

Sample	Elastic Modulus (MPa)	Tensile Strength (MPa)	Elongation at Break (%)
L-PE	1080	27	800
H-PE	950	22	> 1000
H-SBH	660	10	8.0
L-SBH	420	11	8.2
COPR	750	17	6.0
COPM	760	13	3.0

Table IIIMechanical Properties of the NeatPolymers

The mechanical properties of the L-PE-H-SBH blend are compared in Table IV with those of the same blend compatibilized with 5% w/w of COPR or COPM, following procedure D. As expected, the addition of an incompatible LCP into PE makes the latter become brittle: the elongation at break drops to less than 5%. The addition of the PE-g-SBH copolymers has the effect of doubling this parameter. This effect, though being accompanied by a slight reduction of elastic modulus (probably due to the low modulus of the COPs) and failing. therefore, to improve the tenacity, confirms that both copolymers do, in fact, improve the interphase adhesion of these blends in the solid state too. Although the difference between the two graft copolymers appears almost negligible, that synthesized by melt polycondensation (COPR) seems slightly more effective.

The effect of the molar mass of the matrix on the mechanical properties of the PE–H-SBH blends, with and without COPM addition, is illustrated by the data in Table V. The ternary blends were prepared by route D. The tensile strength does not vary appreciably, neither with the molar mass of the PE matrix, nor with the compatibilizer addition. As far as the elastic modulus is concerned, this is expectedly smaller for the blends with H-PE and decreases slightly upon addition of COPM. The elongation at break of both uncompatibilized blends is very low, although the blend with H-PE is expectedly less fragile. As already pointed out before, the presence of the COPM compatibilizer brings about a noticeable increase of the elongation at break. The effect is smaller for the H-PE-H-SBH blend, in agreement with the conclusion of the rheological and morphological characterization.

The mechanical properties of the blends of L-PE with the two different samples of SBH, either with and without compatibilizer, are shown in Table VI. The blend with L-SBH has lower modulus, in agreement with expectation based on the elastic moduli of the pure LCPs shown in Table III. However, this blend shows better ultimate properties. This is certainly due to the finer dispersion of the L-SBH droplets already demonstrated by the morphological analysis [compare Figures 5(b) and 6(a). The properties of the compatibilized blends shown in Table VI confirm that the addition of 5% COPR brings about a noticeable increase of the break elongation. Moreover, for the L-PE-L-SBH blend, that the rheological and morphological characterization had already shown to be best suited to compatibilization with the PE-g-SBH copolymers, elastic modulus and tenacity are also improved, in addition to the elongation at break.

In Table VII, the mechanical properties of the L-PE-H-SBH blends, compatibilized with 5% COPR following the different mixing routes shown in Table II, are reported. No appreciable difference is observed for the Young's modulus even if the blends made by routes A and B present slightly higher values. The same comment can be made for tensile stress. As for the elongation at break, the situation is different; in fact, in agreement with the prediction based on the morphological study, considerably higher elongation values were found for the blends prepared by routes C and D.

Table IVEffect of the Addition of COPR or COPM into the L-PE-H-SBH blendon its Mechanical Properties

Blend ^a	Elastic Modulus (MPa)	Tensile Strength (MPa)	Elongation at Break (%)
L-PE-H-SBH	1050	22.5	4.8
L-PE-H-SBH-COPR	910	23.0	10.6
L-PE-H-SBH-COPM	930	22.0	9.3

^a The compatibilized blends were prepared by route D.

Blend ^a	Elastic Modulus (MPa)	Tensile Strength (MPa)	Elongation at Break (%)
L-PE-H-SBH	1050	22.5	4.8
L-PE-H-SBH-COPM	930	22.0	9.3
H-PE-H-SBH	920	22.0	8
H-PE-H-SBH-COPM	825	22.0	13

Table VEffect of the Molar Mass of the PE Matrix on the Mechanical Propertiesof PE-H-SBH Uncompatibilized and Compatibilized Blends

^a The compatibilized blends were prepared by route D.

CONCLUSIONS

In this work, a rheological, microscopic, and mechanical study of blends of polyethylene with a semiflexible liquid crystal polymer has been carried out in order to gain further information on the influence of a number of features, such as the structure of the compatibilizer, the molar mass of the matrix and the dispersed phase, and the way the blends are prepared, on the morphology and the properties of the blends. Moreover, qualitative indication that the microstructure of the LCP has also an effect on the phase compatibility of these blends has been obtained.

The results indicate that the PE-g-LCP copolymers synthesized from a commercial oxidized polyethylene sample (PEox) either by reactive blending with a LC copolyester (SBH), or by melting it with the SBH monomers during their polycondensation, do actually play a compatibilizing role for the PE-SBH blends and lead to an appreciable improvement of phase dispersion and interfacial adhesion, both in the molten and in the solid state. In addition, the elongation at break of samples of the ternary blends shows a clear, though modest, increase, thus demonstrating that the copolymers do migrate to the interphase and reduce the inherently high brittleness of these blends.

The appropriate choice of the molar mass of the polymers being blended has been shown to be critical in view of the optimization of the blends properties. It is well known, in fact, that the viscosity ratio of the two phases of a blend has a profound effect on its morphology and phase dispersion. For the blends studied in this work, the best results were found by the use of an injection molding grade of PE with a melt index of 11 dg \min^{-1} (L-PE) and a sample of SBH 1 : 1 : 2 with an inherent viscosity of 0.87 dL g^{-1} (L-SBH). Another SBH sample having a slightly higher molar mass (inherent viscosity of 1.0 dL g^{-1}) and a more "blocky" microstructure was found to display worse behavior, thus showing that the latter parameter may also play a role. It was also shown that the compatibilizing effect of the PE-g-SBH copolymers was more evident for the L-PE-L-SBH blend, probably because this provided the best match of the molar mass of the two phases with the lengths of the PE and SBH sequences of the compatibilizer. Finally, the preparation of a master blend of the compatibilizer with only one of the two polymers, followed by the addition of the second one, was shown to yield better results in terms of both morphology and properties.

It may be concluded that despite the highly incompatible nature of polyethylene and liquid crystalline copolyesters, these two polymers can

Table VIEffect of the Molar Mass of the LCP Component on the Mechanical Propertiesof L-PE-SBH Uncompatibilized and Compatibilized Blends

Blend ^a	Elastic Modulus	Tensile Strength	Elongation
	(MPa)	(MPa)	at Break (%)
L-PE-H-SBH	1050	22.5	4.8
L-PE-COPR-H-SBH	910	23.0	10.6
L-PE–L-SBH	972	23.7	$5.8\\11.8$
L-PE–COPR–L-SBH	1022	27.4	

^a The compatibilized blends were prepared by route D.

Mixing Procedure	Elastic Modulus (MPa)	Tensile Strength (MPa)	Elongation at Break (%)
А	1057	24.7	7.3
В	1077	24.8	7.9
С	1000	25.2	9.8
D	910	23.0	10.6

Table VII Mechanical Properties of the L-PE-COPR-H-SBH Blends Prepared by Different Procedures

be blended to give reasonably compatible morphologies, provided the addition of purposely synthesized PE-g-LCP copolymers is made, and the molar mass of the components and the blending procedures are appropriately selected. However, the results are still far from satisfactory, and it can be forecast that further study is necessary before the PE-LCP blends can meet a practical application.

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