

Increasing the Compatibility of Poly(L-lactide)/Poly(*para*-dioxanone) Blends Through the Addition of Poly(*para*-dioxanone-co-L-lactide)

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ABSTRACT: To modify the mechanical properties of a poly(L-lactide) (PLLA)/poly(*para*-dioxanone) (PPDO) 85/15 blend, poly(*para*-dioxanone-co-L-lactide) (PDOLLA) was used as a compatibilizer. The 85/15 PLLA/PPDO blends containing 1–5 wt % of the random copolymer PDOLLA were prepared by solution coprecipitation. Then, the thermal, morphological, and mechanical properties of the blends with different contents of PDOLLA were studied via differential scanning calorimetry (DSC), scanning electron microscopy (SEM), and tensile testing, respectively. The DSC result revealed that the addition of PDOLLA into the blends only slightly changed the thermal properties by inhibiting the crystallization degree of the poly(L-lactide) in the polymer blends. The SEM photos indicated that the addition of 3 wt % PDOLLA into the blend was ideal for making the interface between the PLLA and PPDO phases unclear. The tensile testing result demonstrated that the mechanical properties of the blends containing 3 wt % PDOLLA were much improved with a tensile strength of 48 MPa and a breaking elongation of 214%. Therefore, we concluded that the morphological and mechanical properties of the PLLA/PPDO 85/15 blends could be tailored by the addition of the PDOLLA as a compatibilizer and that the blend containing a proper content of PDOLLA had the potential to be used as a medical implant material. © 2014 Wiley Periodicals, Inc. *J. Appl. Polym. Sci.* **2015**, *132*, 41323.

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INTRODUCTION

Biodegradable polymers are used increasingly in biomedical applications^{1,2} because medical devices made of biodegradable polymers can be biodegraded and discharged out of the body through metabolism. Thus, patients will be able to avoid a second operation to take the medical devices out of the body, during which patients can suffer a lot of pain. Poly(L-lactide) (PLLA) is one of the most extensively studied polymers for medical applications and has been approved for direct contact with biological fluids by the U.S. Food and Drug Administration³ because it is biocompati-

ble and biodegradable and has a high tensile strength and modulus^{4–7} compared with other biodegradable polymers. However, PLLA is a very brittle material with an elongation at break of less than 10%.³ To toughen PLLA, methods such as copolymerization with other monomers and blending with flexible (co)polymers have been used.^{8,9} Blending is usually more practical and economical compared to copolymer synthesis.^{9–11} PLLA has been blended with flexible polymers such as poly(ϵ -caprolactone) (PCL),^{1,4,12–14} poly(*para*-dioxanone) (PPDO),^{10,15} poly(β -hydroxybutyrate-co- β -hydroxyvalerate),¹⁶ poly(butylene succinate),^{17–19} and others.^{20,21}

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Even though these materials are biodegradable, the mechanical properties of most of them are not ideal. Because most binary blends are immiscible, the macrophase separation of the two components and the low adhesion between the phases occurs, and this results in unideal mechanical properties.¹

Compatibilization is essential for obtaining blends with good mechanical properties because the decrease of macrophase separation and the increase of the adhesion between the phases can be achieved by compatibilization. As is well known, the mechanical properties of a multiphase blend are usually affected by the ability of the interface to transmit stress from one phase to the other.⁸ An amorphous phase with a low glass-transition temperature (T_g) has an elevated chain mobility under ambient conditions to absorb and dissipate applied stress;²² this will enhance the toughness of the material. Compatibilization is usually achieved by the addition of polymers with emulsifying properties, such as graft or block copolymers into the blends.²³ The main function of a compatibilizer in blends is to increase the surface adhesion between the two polymers and increase their miscibility degree,² so as to benefit the stress transmission between the two phases.

PPDO is a highly flexible polymer with excellent biocompatibility and a rapid degradation rate.^{10,24,25} PPDO has been added to PLLA to toughen it; however, the mechanical properties are not ideal because of the immiscibility of PLLA and PPDO.^{10,15} The melt-blending and solution-blending methods can be used to prepare polymer blends. An extruder and mixer are often used in polymer melt mixing. In the solution-blending method, polymers are dissolved in one or two solvents; then, the solvent is separated from the uniform solution mixture. Compared with melt blending, the solution-blending method favors a good dispersion of the polymer with low content. To obtain a uniform dispersion of PPDO in the PLLA matrix, PLLA/PPDO blends with different contents of PPDO were prepared by solution coprecipitation, and then, blend bars for testing were processed by compression molding. The thermal, morphological, and mechanical properties of the blends were studied. We found that the T_g of PLLA changed slightly, phase separation occurred in the blends, and the mechanical properties were much poorer, all of which indicated that PLLA and PPDO were immiscible. This work was not reported because of the poor mechanical properties obtained and the lack of a valuable innovation. Increasing the compatibility of PLLA and PPDO is necessary to obtain a blend with ideal mechanical properties. In this study, various contents of poly(*para*-dioxanone-*co*-*l*-lactide) (PDOLLA) were added to PLLA/PPDO 85/15 blends by solution coprecipitation to increase their compatibility and tailor their mechanical properties.

EXPERIMENTAL

Materials

The PLLA and PPDO polymers used in this study were synthesized by the ring-opening polymerization of *l*-lactide (LLA) and *para*-dioxanone (PDO), as described in our previous articles.^{26,27} The intrinsic viscosity ($[\eta]$) of PLLA and PPDO were 5.6 and 1.4 dL/g, respectively. The viscosity-average molecular weights (M_v 's) of PLLA and PPDO were 313,100 and 51,700 g/mol, respectively, and were calculated from $[\eta]$ with eqs. (1) and (2), as reported for PLLA by Garlotta²⁸ and for PPDO by Chen et al.²⁹

$$[\eta] = KM_v^\alpha \quad (1)$$

where α is 0.73 and K is 5.45×10^{-4} dL/g (PLLA in chloroform at 25°C)

$$[\eta] = KM_v^\alpha \quad (2)$$

where α is 0.69 and K is 79×10^{-3} cm³/g [PPDO in hexafluoroisopropanol (HFIP) at 25°C].

HFIP was purchased from Sinochem Lantian Co., Ltd. (Hangzhou, China). Other analytical-reagent-grade solvents were purchased from Guangdong Guanghua Sci-Tech Co., Ltd. (Shantou, China). All solvents were used without further purification.

Amorphous PDOLLA used as a compatibilizer for the PLLA/PPDO blends was synthesized and characterized as described in our previous article.³⁰ The average molecular weights of the random copolymer measured with gel permeation chromatography (Waters 1515-Styragel HT4 and 5–2414; Waters Corp., Milford, MA) were as follows: number-average molecular weight = 85,400 and weight-average molecular weight = 150,300. The T_g of PDOLLA was determined by differential scanning calorimetry (DSC) to be 3.06°C.

Preparation of the Blends

The composition of all of the blends was fixed at 85/15 (PLLA/PPDO) by weight. The PLLA/PPDO blends with 0, 1, 3, and 5 wt % compatibilizer were prepared by solution coprecipitation. PLLA was dissolved in dichloromethane to produce a 5 w/w% solution, and PPDO and PDOLLA were dissolved together in HFIP to produce a 2.5 w/w% solution. The two solutions were then mixed in a beaker. The resulting mixture was stirred for 20 min, and the blends were precipitated by the addition of excess alcohol. The resulting materials were dried *in vacuo* at 40°C for 48 h to remove the remaining solvent and to establish phase equilibrium before the physical measurements.

The blends were formulated on the basis of parameters outlined in ASTM D 638. Bars with $50 \times 5 \times 0.5$ mm³ dimensions were prepared with a platen vulcanizing press (model XLB, Shanghai Light Industry Machinery Co., Ltd., Shanghai, China) at 200°C and 5.5 MPa for 12 min. The bars were then quenched to room temperature by immersion in water.

¹H-NMR

The ¹H-NMR spectrum of PDOLLA was recorded at 300 MHz on a Bruker AV300 spectrometer (Germany). Deuterated chloroform was used as the solvent with tetramethylsilane as the chemical shift standard.

DSC

DSC was performed with a TA differential scanning calorimeter (model CMT 4503). The samples were carefully loaded into aluminum pans, heated to 200°C at a rate of 10°C/min, maintained at this temperature for 3 min to erase the thermal history, cooled to -40°C at a rate of 50°C/min, and finally heated to 200°C at a rate of 10°C/min.

Scanning Electron Microscopy (SEM)

The morphologies of the fracture surfaces of the sample bars were examined with a JEOL scanning electron microscope

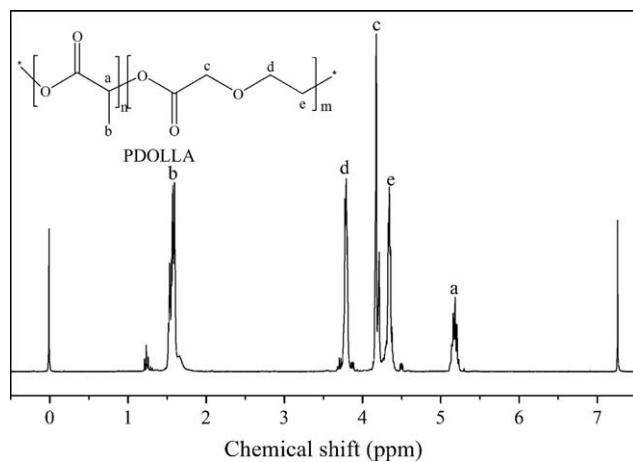


Figure 1. $^1\text{H-NMR}$ spectra of PDOLLA.

(model Inspect F) after the sample was coated with a thin layer of gold by vacuum deposition.

Tensile Testing

The blends were tested based on the parameters outlined in ASTM D 882–2010. Bars with $50 \times 5 \times 0.5 \text{ mm}^3$ dimensions were measured at a drawing speed of 10 mm/min in an environment with a temperature 25°C and a relative humidity of 60% with a SANS tensile tester (model CMT 4503; MTS Systems Co., Ltd., Shenzhen, China). Each reported value was the mean of three replicate samples.

X-ray Diffraction (XRD)

The blends were studied by XRD with a Philips X-ray diffractometer (model X'Pert Pro, Koninklijke Philips Electronics N.V., Amsterdam, The Netherlands) equipped with a Ni-filtered Cu K α ($\lambda = 0.1542 \text{ nm}$) radiation source operated at 40 kV and 30 mA. Samples were scanned in the 2θ range from 5 to 40° .

RESULTS AND DISCUSSION

$^1\text{H-NMR}$

The $^1\text{H-NMR}$ spectrum of PDOLLA is shown in Figure 1. The peaks at 5.18 and 1.55 ppm were assigned to the $-\text{CH}-$ group protons (labeled *a* in Figure 1) and $-\text{CH}_3$ group protons

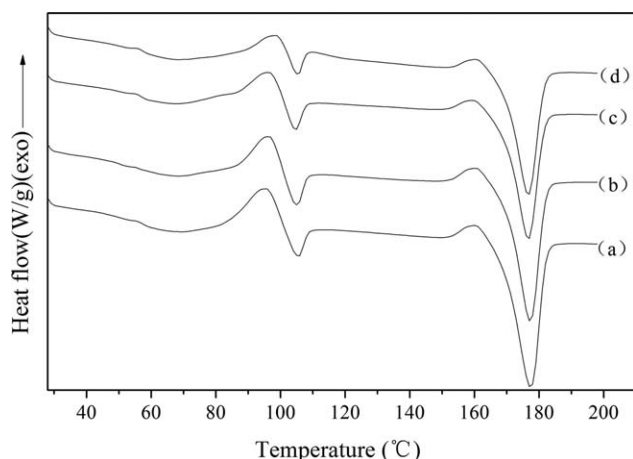


Figure 2. DSC curves for the PLLA/PPDO blends with different contents of PDOLLA during the first heating: (a) 0, (b) 1, (c) 3, and (d) 5%.

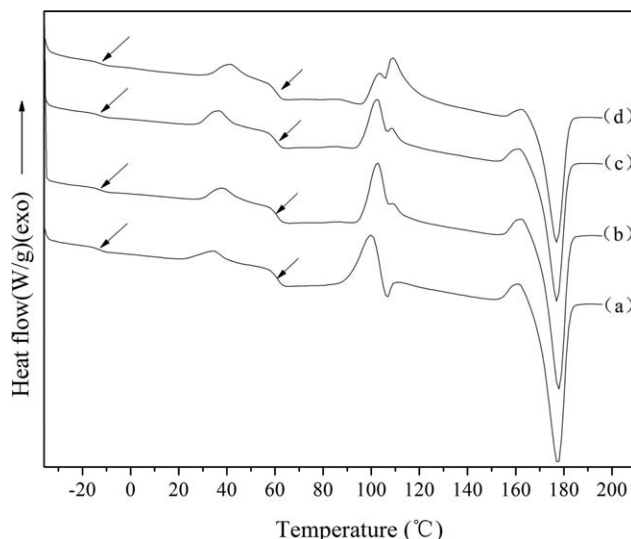


Figure 3. DSC curves for the PLLA/PPDO blends with different contents of PDOLLA during the second heating: (a) 0, (b) 1, (c) 3, and (d) 5%.

(labeled *b* in Figure 1) of the LLA segment, respectively.³⁰ The peaks at 4.34, 3.79, and 4.17 ppm were assigned to the protons of the three $-\text{CH}_2-$ groups (labeled *c–e* in Figure 1) in the PDO segment.^{27,30} The ratio of PDO to LLA units in the PDOLLA used in this study was calculated from the $^1\text{H-NMR}$ spectrum to be $\text{PDO/LLA} = 1.17$.

Thermal Analysis

The DSC curves for the first and second heating of the PLLA/PPDO blends containing different PDOLLA contents are shown in Figures 2 and 3, respectively. The crystallization peak temperature (T_c), crystallization enthalpy (ΔH_c), melting peak temperature (T_m), melting enthalpy (ΔH_m), where m is mass, and T_g values of the blends were determined from DSC thermograms, and the results are summarized in Tables I and II. In the first and second heating, the values of the crystallization degree of the poly(L-lactide) (X_{PLLA}) were calculated by eqs. (3) and (4), respectively. ΔH_m^c is the melting enthalpy of completely crystalline PLLA, and was assumed to be 93 J/g .^{31,32} X_{PLLA} is the weight fraction of PLLA in the blend calculated by eq. (5). The weight fraction of LLA in PDOLLA in eq. (5) was calculated from the $^1\text{H-NMR}$ spectrum to be 0.38. According to eq. (3), we calculated the crystallinity of the sample bars because the crystallinity of the sample bars had a great influence on the mechanical properties. According to eq. (4), we calculated the crystallinity of the blends after the rapid cooling and second heating in the DSC process. The effects of different contents of PDOLLA on the crystallization were studied by comparisons of the crystallinity calculated from eq. (4) and ΔH_m obtained from the second heating:

$$X_{\text{PLLA}} = \frac{\Delta H_m - \Delta H_c}{\Delta H_m^c \times X_{\text{PLLA}}} \quad (3)$$

$$X_{\text{PLLA}} = \frac{\Delta H_m}{\Delta H_m^c \times X_{\text{PLLA}}} \quad (4)$$

$$X_{\text{PLLA}} = \frac{m(\text{PLLA}) + 0.38m(\text{PDOLLA})}{m(\text{PLLA}) + m(\text{PPDO}) + m(\text{PDOLLA})} \quad (5)$$

As shown in Table I, the crystallizations of the blend samples with 0, 1, 3, and 5 wt % PDOLLA were 33, 33, 32, and 34%,

Table I. DSC Data for the PLLA/PPDO Blends with Different Contents of PDOLLA Obtained from the First Heating

Compatibilizer content (wt %)	PLLA				
	T_c (°C)	ΔH_c (J/g)	T_m (°C)	ΔH_m (J/g)	X_{PLLA} (%)
0	95.73	14.54	177.32	40.66	33.04
1	96.74	10.90	177.24	37.01	33.21
3	96.77	7.421	176.64	32.53	32.28
5	98.56	5.051	176.63	31.48	34.34

respectively; this suggested that the addition of PDOLLA did not affect the crystallization of PLLA by the process we chose. The crystallization of the polymers affected their mechanical properties. A high crystallization led to a high tensile stress and small breaking elongation, whereas a low crystallization led to a low tensile stress and large breaking elongation. In this study, the nearly same crystallization of the sample bars with different contents of PDOLLA did not affect the evaluation of the improvement of the compatibility of the PLLA/PPDO blends through a comparison of their mechanical properties.

As shown in Table II, the T_g values of PLLA in the blends with 0, 1, 3, and 5 wt % PDOLLA were 61.3, 60.6, 60.7, and 61.2°C, respectively. The T_g values of PPDO in the blends with 0, 1, 3, and 5 wt % PDOLLA were -13.3, -12.7, -13.0, and -12.6°C, respectively. The T_g of PLLA decreased slightly to about 61°C with the addition of PDOLLA, whereas the T_g of PPDO increased slightly to approximately -13°C. The fact that the T_g 's of PLLA and PPDO shifted toward each other suggested that the miscibility of PLLA and PPDO was improved. In our earlier study,³³ the T_g 's distance between PLLA and PPDO was shortened with the addition of PLADO (copolymer) for the same reasons. However, it was difficult to detect the T_g of PDOLLA in the blends because of the low PDOLLA content.²¹ When the content of PDOLLA increased from 0 to 5 wt %, the T_c of PLLA increased from 100.34 to 108.65°C, whereas ΔH_m of PLLA decreased. The crystallization of PLLA was calculated from its ΔH_m values; the crystallizations of PLLA in the blends with 0, 1, 3, and 5 wt % PDOLLA were 49.30, 42.67, 40.29, and 37.98%, respectively. The increase in T_c and the decrease in crystallization with increasing PDOLLA content in the second heating indicated that the addition of PDOLLA inhibited the crystallization of PLLA. This result was in agreement with a

report¹⁷ demonstrating that the addition of dicumyl peroxide into PLLA/poly(butylene succinate) blends inhibited the crystallization of PLLA. Finally, the T_g 's of PLLA and PPDO and the T_c and T_m of PLLA in the blends were observed to change slightly upon PDOLLA addition; this decreased the final ΔH_m . The addition of a copolymer to a blend of immiscible polymers, particularly at the low contents described in this study, may influence the dispersion state of the two polymers by reducing the interfacial tension while not necessarily affecting bulk properties, such as the crystallization behavior or glass transitions.¹¹

Morphologies

We obtained the fracture surfaces by fracturing molded bars for testing in liquid N₂. To ensure that images taken were not subjective, we took five SEM photos of the fracture surfaces of each blend bar at different points. Then, we found that the five images of each group were nearly the same and then chose one of the five to present in this article (in the Supporting Information). Figure 4 shows the SEM images of the fracture surfaces. As shown in Figure 4(a), the interface between PLLA and PPDO and the boundary between the dispersed phase and the PLLA matrix was clearly observed. Small holes with various diameters were also detected. The macrophase separation of the blend was attributed to the immiscibility of the PLLA/PPDO blend.¹⁰ Pezzin et al.¹⁰ also observed phase separation for all compositions of the PLLA/PPDO blends. Stress concentration usually occurs in the vicinity of the dispersed phase separations because of differences in the elastic modulus between the dispersed phase and the surrounding matrix, and it initiates localized microdamage in this region.³⁴ The addition of 1 wt % PDOLLA as a compatibilizer to the PLLA/PPDO blend did not generate obvious changes in the interface [Figure 4(b)] because the low content of PDOLLA was not enough to generate a strong interfacial adhesion between the surfaces of PLLA and PPDO. However, as shown in Figure 4(c), the morphology of the phase interface was changed significantly by the addition of 3 wt % PDOLLA; the voids disappeared, and the interface became unclear. This was attributed to a reduction in the interfacial tension between the dispersed phase and the PLLA matrix.³³ This represented an improvement in the compatibilization and interfacial adhesion of the PLLA/PPDO blend.^{17,33} For the PDOLLA content of 5 wt %, small holes with various diameters reappeared, and the boundary between the dispersed phase and the PLLA matrix was again detected. This result was attributed to a new phase formed by the excess PDOLLA, a

Table II. DSC Data for PLLA/PPDO Blends with Different Contents of PDOLLA Obtained from the Second Heating

Compatibilizer content (wt %)	PLLA						
	PPDO T_g (°C)	T_g (°C)	T_c (J/g)	ΔH_c (J/g)	T_m (°C)	ΔH_m (J/g)	X_{PLLA} (%)
0	-13.29	61.34	100.34	11.32	177.42	38.97	49.30
1	-12.67	60.60	102.67	13.12	177.91	33.49	42.60
3	-13.01	60.67	102.41	11.59	177.08	31.19	40.10
5	-12.62	61.16	108.65	14.84	176.99	29.01	37.69

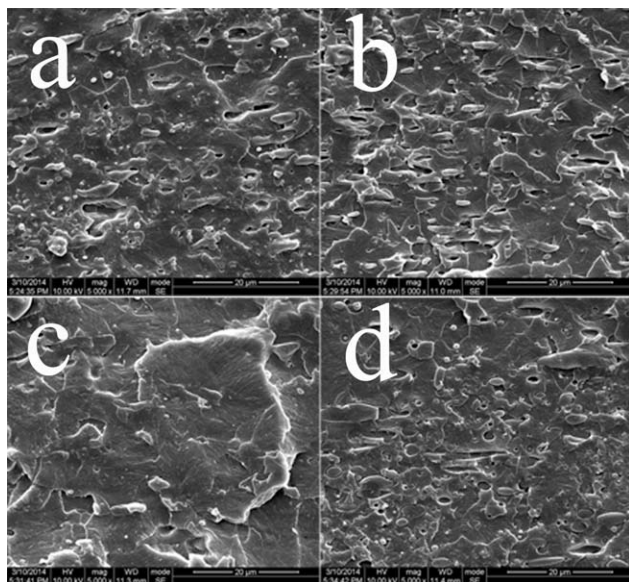


Figure 4. Scanning electron micrographs of the fracture surfaces of the PLLA/PPDO blends with different contents of PDOLA: (a) 0, (b) 1, (c) 3, and (d) 5%.

phenomenon reported in a previous study.³³ The morphological analysis of PLLA/PPDO demonstrated that the addition of various amounts of PDOLA could be used to obtain different properties of the polymer blends.

Mechanical Properties

The tensile properties of the PLLA/PPDO blends with 0, 1, 3, and 5 wt % PDOLA are shown in Figures 5 and 6. The blend without PDOLA had a high tensile strength and limited breaking elongation. As shown in Figure 5, the tensile strength of the blends dropped slightly with the addition of PDOLA; this was attributed to the increase in the weight ratio of the flexible PDO chain segment. The tensile strengths of the blends with 0, 1, 3, and 5 wt % PDOLA were 51 ± 1 , 49 ± 1 , 48 ± 2 , and 40 ± 1 MPa, respectively. Because the ratios of PLLA and PPDO changed a little and the crystallinity of the prepared blend bars was not much different (see Table I), the tensile strength of the bars was not much different. However, Figure 6 shows that the breaking elongations of the blend with 0, 1, 3, and 5 wt % PDOLA were 26 ± 9 , 24 ± 4 , 214 ± 76 , and $25 \pm 3\%$, respectively. The breaking elongation of the blend with 3 wt % increased significantly by 719 to $214 \pm 76\%$ compared to the elongation without PDOLA ($26.33 \pm 9.40\%$). The tensile strength decreased by 7% to 48 ± 2 MPa at this PDOLA content, compared to the strength of 51 ± 1 MPa without PDOLA. This result agreed with those of Hiljanen-Vainio,³⁵ where it was reported that the addition of certain contents of the poly(caprolactone-co-l-lactide) copolymer into the PLLA/PCL 80/20 blends led to a slight decrease in the tensile strength and a large increase in the breaking elongation. The breaking elongations of the PLLA/PPDO blends with 1 and 5 wt % PDOLA were nearly same as those without PDOLA; this was probably due to the phase-separated morphologies of the blends discussed previously.

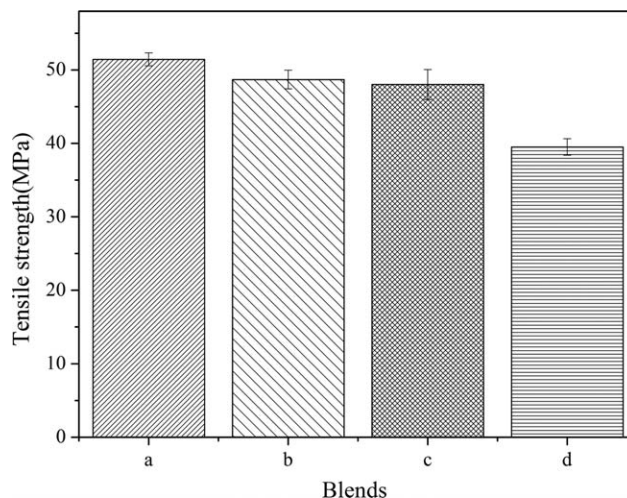


Figure 5. Tensile strength of the PLLA/PPDO blends with different contents of PDOLA: (a) 0, (b) 1, (c) 3, and (d) 5%.

The PLLA/PPDO 85/15 blend with 3 wt % PDOLA had a large breaking elongation without any sacrifice to the tensile strength of the blend without PDOLA. This mechanical advantage occurred because of the disappearance of the holes and the interface in the blend, as shown in the SEM morphological analysis; this favored the passing of stress from one phase to the other. Our result was consistent with the conclusion from another report.¹ The macrophase separation of the two components and the low adhesion between the phases observed in the PLLA/PPDO blends with 0, 1, and 5 wt % PDOLA demonstrated a much smaller breaking elongation compared to the blend with 3 wt % PDOLA. This phenomenon was also found in a study reported by Na et al.³¹ In their study, PCL-*b*-poly(ethylene glycol) (PEG) was added as a compatibilizer to poly(lactide)/PCL binary blends. The strain at break and the modulus increased gradually up to 10 wt % PCL-*b*-PEG, although the maximum stress decreased slightly. The PLLA/PCL blend film containing 10 wt % PCL-*b*-PEG showed an increase in the breaking elongation of about 20% in comparison with the blend

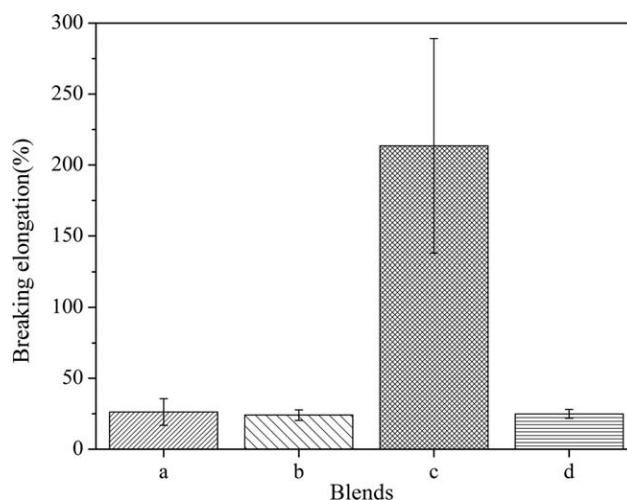


Figure 6. Breaking elongation of the PLLA/PPDO blends with different contents of PDOLA: (a) 0, (b) 1, (c) 3, and (d) 5%.

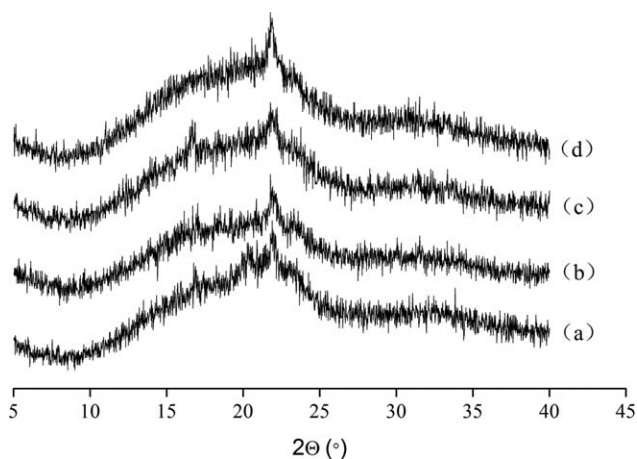


Figure 7. X-ray diffractograms of the PLLA/PPDO blends with different contents of PDOLLA: (a) 0, (b) 1, (c) 3, and (d) 5%.

film containing no block copolymer. All of the mechanical properties decreased for the PLLA/PCL 80/20 film containing 15 wt % PCL-*b*-PEG. The results supplied previously indicated that there existed an optimum copolymer concentration to improve the immiscible polymer blends.³¹ These observations indicated that the mechanical properties of the immiscible blends were strongly dependent on their morphologies, and therefore, the morphological control of immiscible polymer blends is of vital importance in tailoring the final properties of the product.¹¹

The PLLA/PPDO 85/15(w/w) blend with 3 wt % PDOLLA in this study has the potential to be used as a medical material because the sample bars we prepared had nice mechanical properties. Both the good mechanical properties and SEM images indicated that this blend was compatible. The toughening of PLLA by blending has been widely studied; however, sample bars with these good mechanical properties have rarely reported.^{36,37} Most researchers have reported that PLLA blends achieved large breaking elongation with a sacrifice to their tensile strength. However, a few PLLA blends with good mechanical properties have been reported recently. Lin et al.³⁸ studied polylactide/poly(butylene adipate-*co*-terephthalate) 70/30 blends with different contents of tetrabutyl titanate, which were blended reactively. They found the blends with 0.5 wt % tetrabutyl titanate gave values of tensile strength and elongation at break of 45 MPa and 298%; this was similar to our results. A similar result was also reported by Chen et al.,³⁹ who obtained this by inhibiting phase separation and crosslinking PLLA and PCL via the addition of dicumyl peroxide. Therefore, the addition of copolymer reported by us or the addition of reactive reagents mentioned previously into the blends, especially immiscible blends, can change the inner morphology of the blends and improve their mechanical properties.

XRD Analysis

The XRD patterns of the PLLA/PPDO blends with various contents of PDOLLA were investigated to obtain further insight into the sample crystallinity, as shown in Figure 7. The major peak of PPDO at approximately $2\theta = 22^{\circ}$ was detected in all of

the blends. However, the characteristic peaks ($2\theta = 14.8$ and 16.7°)²¹ of PLLA were not detected (Figure 7) because the crystallization of PLLA was too low to be detected. This finding was consistent with the result reported by Wang et al.,¹⁷ who also found a broad diffraction peak of neat PLLA with low crystallinity. Because the blend bars were manufactured by a quenching method, PLLA hardly crystallized in the rapid cooling process. The XRD patterns of the blends (Figure 7) exhibited broad diffraction peaks and were all nearly the same. This phenomenon indicates that the crystallinity of all of the samples was low and nearly the same; this was consistent with the former result derived from DSC.

CONCLUSIONS

In this study, a PLLA/PPDO 85/15 blend containing various concentrations of the compatibilizer PDOLLA were prepared by solvent coprecipitation, and their thermal, morphological, tensile, and crystalline properties were studied. DSC analysis revealed that the addition of PDOLLA to the PLLA/PPDO blends hardly changed their thermal properties, with the exception that PDOLLA inhibited the crystallization of PLLA. DSC also revealed that the PLLA in all of the samples had nearly the same crystallinity (ca. 33%). SEM analysis revealed that the addition of 3 wt % PDOLLA resulted in an almost uniform morphology of the PLLA/PPDO 85/15 blend. The compatibility of the blend was not increased by 1 wt % PDOLLA, and the addition of 5 wt % PDOLLA exceeded the ideal compatibilizer content; this resulted in a new dispersed PDOLLA phase. Tensile analysis indicated that the 3 wt % PDOLLA blend had the largest breaking elongation ($214 \pm 76\%$) and retained a tensile strength of 48 ± 2 MPa. The tensile properties of this blend were consistent with the morphology indicated by SEM. The PLLA/PPDO 85/15 blend with 3 wt % PDOLLA (PDO/LLA = 75/25) prepared in this study was shown to have potential as a biomedical material because of its biodegradability, biocompatibility, and excellent mechanical properties.

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