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Correlation of morphology and rheological response of interfacially modified PTT/m-LLDPE blends with varying extent of modification

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Abstract

Morphology and rheology of poly(trimethylene terephthalate)/metallocene linear low-density polyethylene (PTT/m-LLDPE) immiscible blends with varying extent of compatibilization were experimentally examined and theoretically analyzed using Palierne and Coran models. A glycidyl methacrylate-based terpolymer was used to modify the interface of the blend. The particle radius in the PTT75/m-LLDPE25 system decreases in proportion to the level of added compatibilizer up to 5 wt% of terpolymer, beyond which the particle size remains unchanged. This is attributed to the saturation of interface by interfacial modifier leading to diminish the effectiveness of the compatibilizer. Morphological observations reveal that the saturation of the interface for PTT25/m-LLDPE75 system occurs at 2.5 wt% compatibilizer content. Rheological examinations show a sharp reduction of complex viscosity for the latter system at 10 wt% terpolymer which is ascribed to the micelle formation in the bulk phase. Plots of the relaxation time spectrum exhibit that upon addition of the compatibilizer the magnitude of the relaxation peaks associated with interface increases which is ascribed to the increase of the interfacial area. The Palierne model fails to predict admissible values and reasonable trend for interfacial tension. This failure is believed to be due to the excessively large difference between the complex shear modulus values of the dispersed and matrix phases. However, the Coran model used to describe the dynamic moduli, shows a good fit to the experimental data.

Keywords: Rheology; Morphology; Poly(trimethylene terephthalate)

1. Introduction

The rheology and morphology of multiphase polymer blends are strongly affected by interfacial characteristics. Most of the efforts performed to date address the rheological behavior of immiscible blends [1–7]. In these systems, a more stabilized morphology with finer dispersed phase can be reached by reducing interfacial tension. Compatibilization is a well-established route to enhance adhesion and reduce interfacial tension between phases in immiscible blends. This can be achieved by either addition of a block copolymer to the system or carrying out an in situ reaction between blend components [8–18].

In a polymer blend compatibilized by a block or graft copolymer, part of the compatibilizer anchors along the interface and chemically or physically interacts with blend components to form an interphase with broader thickness. In the chemically compatibilized blends, interfacial reaction products are new copolymers having higher molecular weights than that of original macromolecules which leads to increase the blend viscosity [8,10,19–24]. Moan et al. [25] observed that these new copolymers induce an additional relaxation mechanism, which results in enhanced storage modulus. This new relaxation mechanism, required for the deformed spherical particles to reach their original shape, greatly depends on the amount and the nature of block copolymer used, as suggested by Jacobs et al. [26]. The rest of the compatibilizer is either dissolved or in micelles localized in one or both bulk phases. In common systems concentration of dissolved copolymers in bulk phases are very low. Below the critical micelle concentration (CMC), at which the interface is saturated by the compatibilizer,

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practically all of the copolymer molecules are localized on the interface. At concentrations above CMC, part of the copolymer forms the micelles which reside in one or both bulk phases [27–29]. CMC value is substantially affected by the molecular weight of the compatibilizer as well as the viscosity of the major phase through which the compatibilizer needs to diffuse until reaching the interface [30].

Several models have been proposed to describe either the influence of compatibilizers on the deformation of dispersed phase or to derive rheological parameters such as the complex shear modulus G^*, the storage modulus G' and the loss modulus G'' [31–42]. One of the most appropriate models which accounts for emulsions with viscoelastic matrix and dispersed phase is the Palierne model [31]. This model has widely been employed to depict the rheological response of various blend systems [2,5,6,43–50]. Friedrich et al. [51] reported that the particle size distribution can be derived from measured data if the interfacial tension is known. On the other hand, interfacial tension can also be estimated from particle size distribution using the Palierne model as shown by Asthana et al. [43] and Shi et al. [44]. Also, micromechanical models, such as that of Coran and Patel [52] which reflects the morphology, together with the common series and parallel mixing rule approaches, have been found to be appropriate to describe the observed rheological response [53].

The objective of this work is to describe the correlation between rheology and morphology for the blends of poly(trimethylene terephthalate) (PTT), a recently introduced aromatic polyester, and m-LLDPE in the presence of a terpolymer as a compatibilizer with special reference to the interfacial saturation phenomenon and its consequential effects on the blend characteristics. The Palierne analysis in addition to a micromechanical model, Coran model, are also employed to further analyze the data. This is the first report on the rheology and morphology of PTT/m-LLDPE system.

2. Theoretical basis

2.1. Palierne model

The Palierne analysis can be employed to correlate morphology and rheology of viscoelastic emulsions in the linear viscoelastic range of strain to evaluate the interfacial tension in the presence of an interfacial modifier [25,33,42]. In addition to this analysis, the models due to Oldroyd [54,55] and Choi and Schowalter [37] have also been applied to polymer blends in the dilute and semidilute systems to assess their rheological response [5,35]. However, since, it is supposed that these models can only explain the low-frequency zone not the full-frequency range of rheological behavior, they will not be used throughout this study. Jacobs et al. [30] developed an extended form of the Palierne model, written as,

$$G_{\mathrm{b}}^{*} = G_{\mathrm{m}}^{*}\frac{1+3\int_0^{\infty}\frac{E(\omega,R)}{D(\omega,R)}\nu(R)\mathrm{d}R}{1-2\int_0^{\infty}\frac{E(\omega,R)}{D(\omega,R)}\nu(R)\mathrm{d}R} \tag{1}$$

in which

$$\begin{aligned}E(\omega,R) = {} & [G_{\mathrm{d}}^{*}(\omega)-G_{\mathrm{m}}^{*}(\omega)][19G_{\mathrm{d}}^{*}(\omega)+16G_{\mathrm{m}}^{*}(\omega)]+\frac{4\alpha}{R}\\ & \times[5G_{\mathrm{d}}^{*}(\omega)+2G_{\mathrm{m}}^{*}(\omega)]+\frac{\beta'(\omega)}{R}[23G_{\mathrm{d}}^{*}(\omega)\\ & -16G_{\mathrm{m}}^{*}(\omega)]+\frac{2\beta''(\omega)}{R}[13G_{\mathrm{d}}^{*}(\omega)+8G_{\mathrm{m}}^{*}(\omega)]\\ & +\frac{24\beta'(\omega)\alpha}{R^2}+16\beta''(\omega)\frac{\alpha+\beta'(\omega)}{R^2}\end{aligned}$$

and

$$\begin{aligned}D(\omega,R) = {} & [2G_{\mathrm{d}}^{*}(\omega)+3G_{\mathrm{m}}^{*}(\omega)][19G_{\mathrm{d}}^{*}(\omega)+16G_{\mathrm{m}}^{*}(\omega)]\\ & +\frac{40\alpha}{R}[G_{\mathrm{d}}^{*}(\omega)+G_{\mathrm{m}}^{*}(\omega)]+\frac{2\beta'}{R}[23G_{\mathrm{d}}^{*}(\omega)\\ & +32G_{\mathrm{m}}^{*}(\omega)]+\frac{4\beta''}{R}[13G_{\mathrm{d}}^{*}(\omega)+12G_{\mathrm{m}}^{*}(\omega)]\\ & +\frac{48\beta'(\omega)\alpha}{R^2}+32\beta''(\omega)\frac{\alpha+\beta'(\omega)}{R^2}\end{aligned}$$

where, $G_{\mathrm{b}}^{*}(\omega)$, $G_{\mathrm{m}}^{*}(\omega)$, and $G_{\mathrm{d}}^{*}(\omega)$ represent complex modulus of blend, matrix and dispersed phase, respectively. $\beta'(\omega)$ and $\beta''(\omega)$ are the complex interfacial dilation and shear moduli, respectively. $\nu(R)$ denotes the particle size distribution function while R, α, ω are particle radius, interfacial tension, and strain frequency, respectively. When the deformation of dispersed phase is small enough so that viscoelastic properties remain linear, we can set both β' and β'' to zero. Graebling et al. [33] assuming the particle size distribution being narrow ($R_{\mathrm{v}}/R_{\mathrm{n}} \leq 2$) and interfacial tension to be independent of shear and interfacial area variation, simplified Eq. (3) to

$$G_{\mathrm{b}}^{*} = G_{\mathrm{m}}^{*}\frac{1+3\sum_i \varphi_i H_i(\omega)}{1-2\sum_i \varphi_i H_i(\omega)} \tag{2}$$

where

$$H_i(\omega) = \frac{(4\alpha/R_i)(2G_{\mathrm{m}}^{*}(\omega)+5G_{\mathrm{d}}^{*}(\omega))+(G_{\mathrm{d}}^{*}(\omega)-G_{\mathrm{m}}^{*}(\omega))(16G_{\mathrm{m}}^{*}(\omega)+19G_{\mathrm{d}}^{*}(\omega))}{(40\alpha/R_i)(G_{\mathrm{m}}^{*}(\omega)+G_{\mathrm{d}}^{*}(\omega))+(2G_{\mathrm{d}}^{*}(\omega)+3G_{\mathrm{m}}^{*}(\omega))(16G_{\mathrm{m}}^{*}(\omega)+19G_{\mathrm{d}}^{*}(\omega))}$$

in which, R_i and ϕ_i denote the ith particle fraction radius and the ith volume fraction of dispersed phase, respectively. The interfacial tension can then be estimated by fitting the experimental data to the Palierne model. Using (α) as fitting parameter, the best fit gives the interfacial tension.

2.2. Coran model

The micromechanical model proposed by Coran and

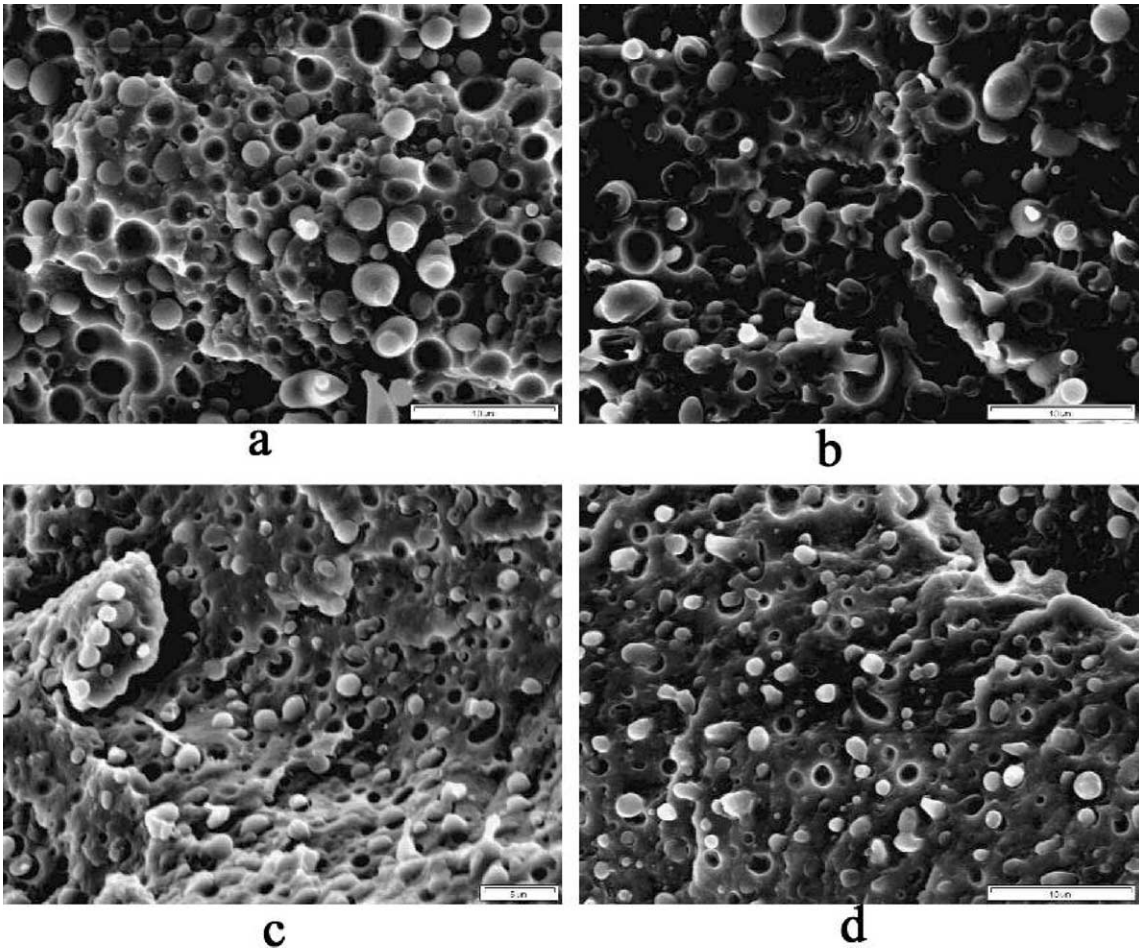


Fig. 1. Micrographs of PTT75/m-LLDPE25 blend with various amounts of compatibilizer: (a) 0 wt%, (b) 2.5 wt%, (c) 5 wt%, (d) 10 wt%.

Patel [52] which is employed to describe the relation between morphology and linear viscoelastic behavior is a weighted addition of a series and a parallel model:

$$G^*_{\text{coran}} = fG^*_{\text{par}} + (1-f)G^*_{\text{ser}} \tag{3}$$

$$G^*_{\text{ser}} = \left[\frac{\varphi_1}{G^*_1} + \frac{\varphi_2}{G^*_2}\right]^{-1} \tag{4}$$

$$G^*_{\text{par}} = \varphi_1 G^*_1 + \varphi_2 G^*_2 \tag{5}$$

where 1 and 2 represent the phase 1 and phase 2, respectively. G_i^* and ϕ_i are the complex modulus and the volume fraction of phase i. The factor f is the degree of applicability of the parallel model and gives a measure for the continuity of the phase with the highest modulus [52].

3. Experimental

3.1. Materials

All the materials used for this work were commercial products and they were used as received without any further treatment. Poly(trimethylene terephthalate), PTT, natural grade Corterra® 200 was obtained from Shell Chemicals. The intrinsic viscosity of the PTT measured at 25 °C in a 60/40 mixture of phenol and tetrachloroethane was 0.9 ml/g. A compatibilizer based on *n*-butyl acrylate glycidyl methacrylate ethylene terpolymer containing 4–5 wt% glycidyl methacrylate (GMA), commercially known as Elvaloy® PTW with melt index of 12.0 g/10 min (ASTM D1238) was obtained from DuPont™. A metallocene linear low-density polyethylene (m-LLDPE), grade 1023CA, with melt index of 1.0 g/10 min (ASTM D1238) was kindly supplied by Exxon Mobile Chemicals. Prior to melt blending the materials were dried for 24 h at 80 °C in a vacuum oven except for the Elvaloy® PTW which was dried at 50 °C for 4 h.

3.2. Melt blending

The PTT/m-LLDPE blends were prepared in a conical twin-screw extruder (DACA Micro Compounder). The screw speed of 100 rpm, temperature of 230 °C and mixing

Table 1
Average particle size and distribution of the blends

PTT/m-LLDPE/ Elvaloy® PTW	R_n (μm)	R_v (μm)	R_v/R_n
75/25/0	0.99	1.40	1.41
75/25/2.5	0.94	1.27	1.35
75/25/5	0.72	0.84	1.17
75/25/10	0.73	0.83	1.18
25/75/0	0.33	0.41	1.24
25/75/2.5	0.22	0.25	1.14
25/75/5	0.21	0.24	1.10
25/75/10	0.21	0.23	1.09

time of 10 min were used for all the blends preparation. Two sets of PTT/m-LLDPE blends with PTT content of 75 wt% and 25 wt% were made with varying amounts of compatibilizer (Elvaloy® PTW content of 0, 2.5, 5 and 10 wt%). About 4 g of each mixture was first dry blended and then fed into the preheated micro-compounder.

3.3. Rheological measurements

The rheological measurements were performed using an ARES oscillatory rheometer (Rheometric Scientific, USA) at 260 °C under nitrogen atmosphere and on a parallel plate geometry (plate diameter of 25 mm, gap of 1–2 mm). Frequency sweeps were carried out between 0.1 and 100 rad/s. The strains used were chosen in order to be within the linear viscoelastic range.

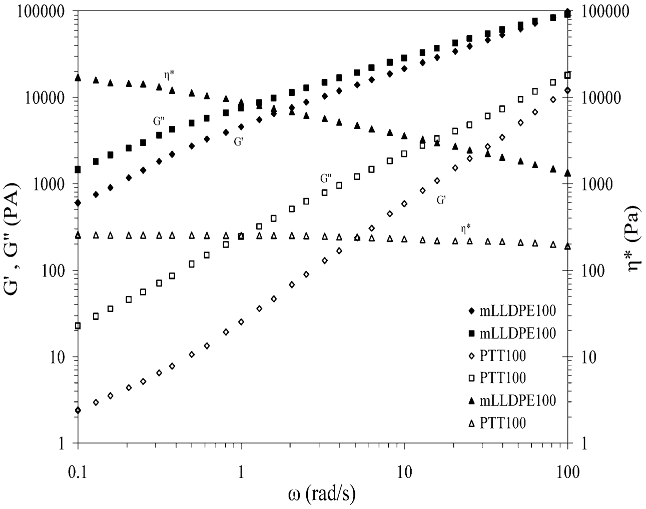


Fig. 3. Dynamic rheological response of neat components.

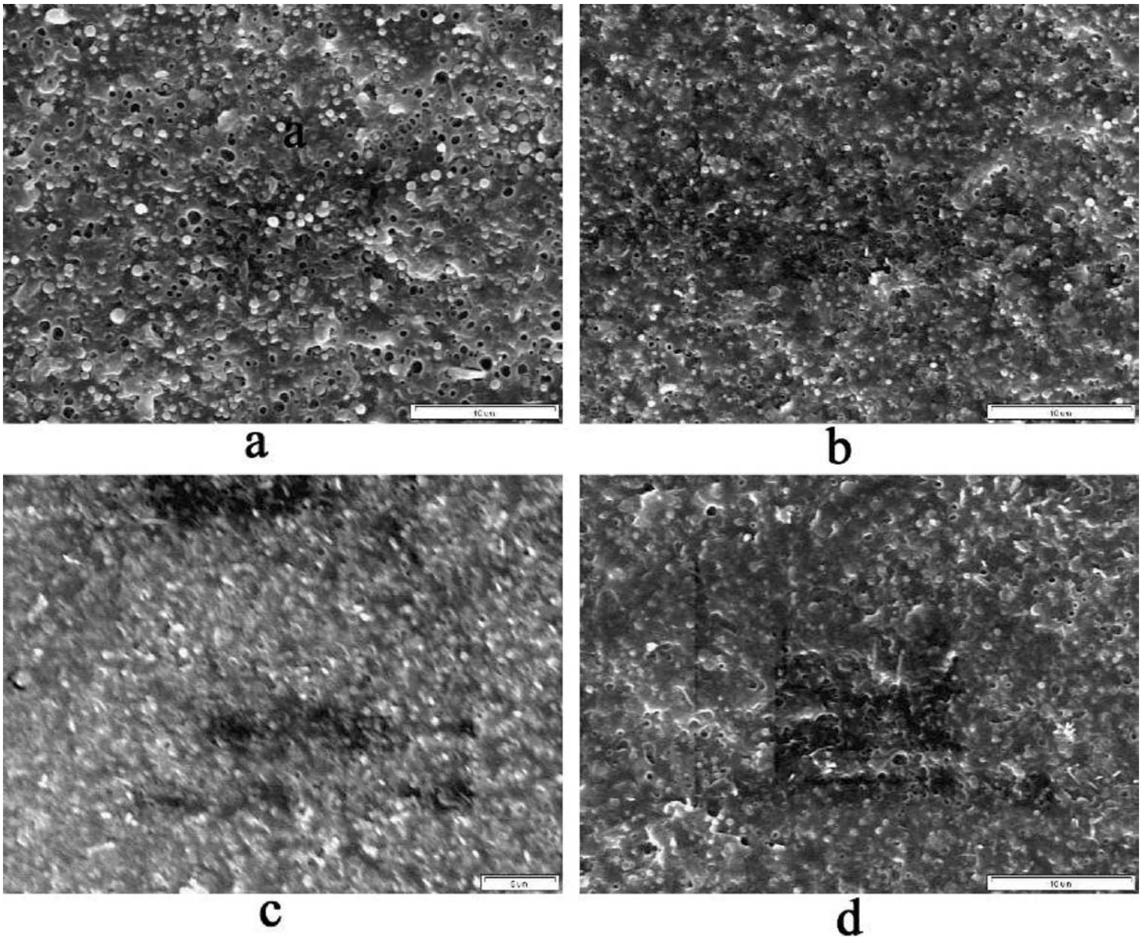


Fig. 2. Micrographs of PTT25/m-LLDPE75 blend with various amounts of compatibilizer: (a) 0 wt%, (b) 2.5 wt%, (c) 5 wt%, (d) 10 wt%.

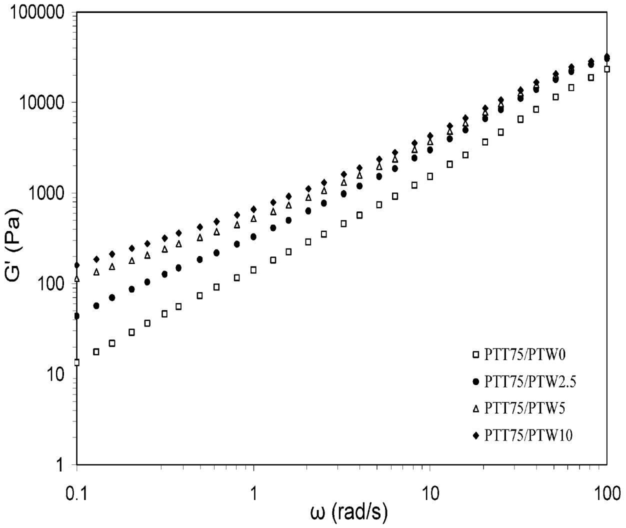


Fig. 4. Dynamic storage modulus of PTT75/m-LLDPE25 system with various amounts of compatibilizer.

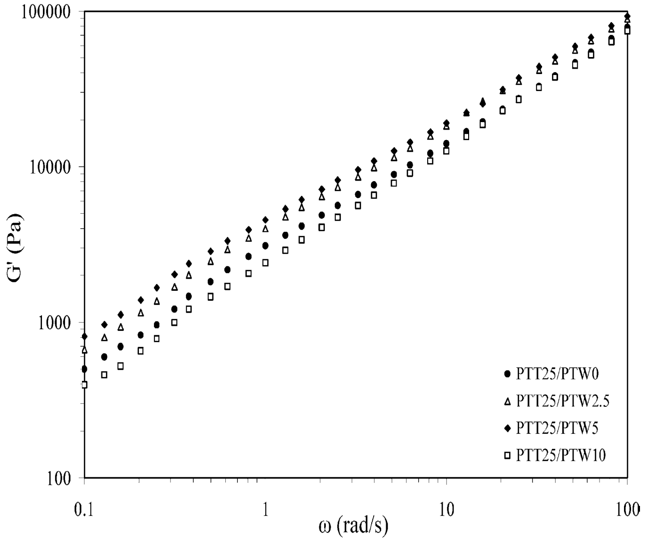


Fig. 6. Dynamic storage modulus of PTT25/m-LLDPE75 system with various amounts of compatibilizer.

3.4. Morphological characterization

The morphology of the cryogenically fractured surface of the extruded strands, after coating with a thin layer of gold, was investigated with a Cambridge S-360 scanning electron microscope (SEM, Cambridge Instruments, MA).

4. Results and discussion

4.1. Blend morphology

Fig. 1(a)–(d) exhibits the micrographs of PTT75/m-LLDPE25 blends with different compatibilizer content (0–10 wt%). The dispersed domains, (m-LLDPE phase), are nearly spherical in all the graphs. It is inferred from this figure that the droplet size progressively decreases up to 5 wt% of compatibilizer. The reduction in droplet size may be attributed to the formation of an interphase resulted from the migration of terpolymer to the interfacial area which anchors along the interface and interacts with blend components leading to decline the interfacial tension and subsequently coalescence suppression. Further addition of terpolymer to the system has no discernible change on the particle size of dispersed phase which may be ascribed to the saturation of the interface with terpolymer. This concludes to diminish the effectiveness of compatibilizer. Similar results have been found by Zhao et al. [30].

On the other hand, coalescence suppression has another substantial effect on the morphology, namely, narrowing the particle size distribution, represented by (R_v/R_n), which is evident from Table 1. No variation of particle size breadth is observed for the blend with 10 wt% of terpolymer as

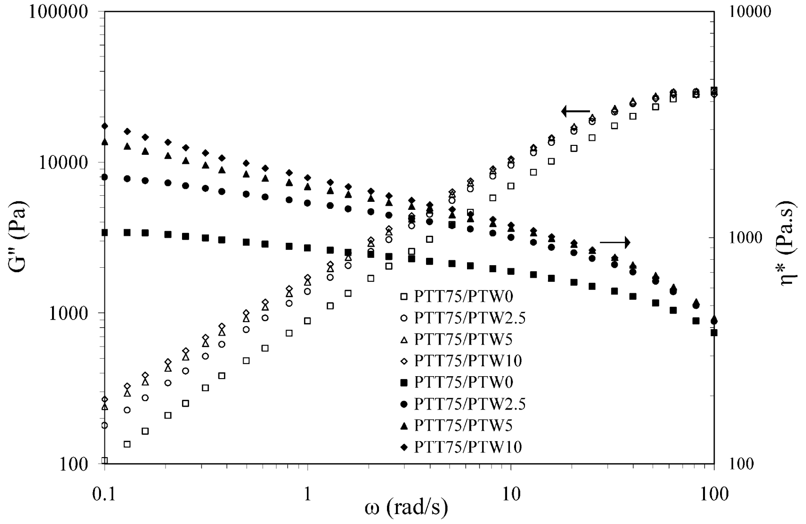


Fig. 5. Dynamic loss modulus and complex viscosity of PTT75/m-LLDPE25 system with various amounts of compatibilizer.

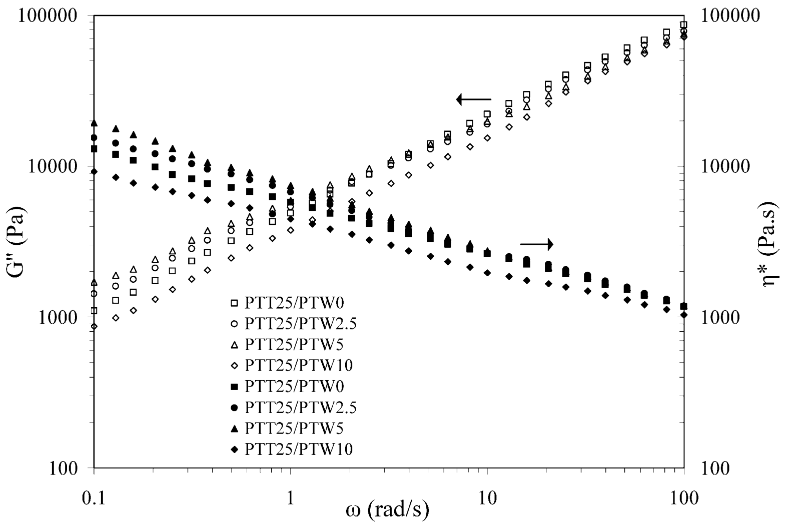


Fig. 7. Dynamic loss modulus and complex viscosity of PTT25/m-LLDPE75 system with various amounts of compatibilizer.

compared to the system containing 5 wt% of the compatibilizer, as clearly demonstrated in this table. This may also be attributed to the saturation of the interface with additional compatibilizer content.

The morphology of PTT25/m-LLDPE75 blends with various amounts of compatibilizer (0–10 wt%) are presented in Fig. 2(a)–(d). All the micrographs show roughly spherical dispersed domains which correspond to PTT phase. The introduction of the terpolymer to this system reduces the droplet size as well, but only up to 2.5 wt% level of compatibilizer indicating a lower CMC limit for this composition as compared with that of PTT75/m-LLDPE25.

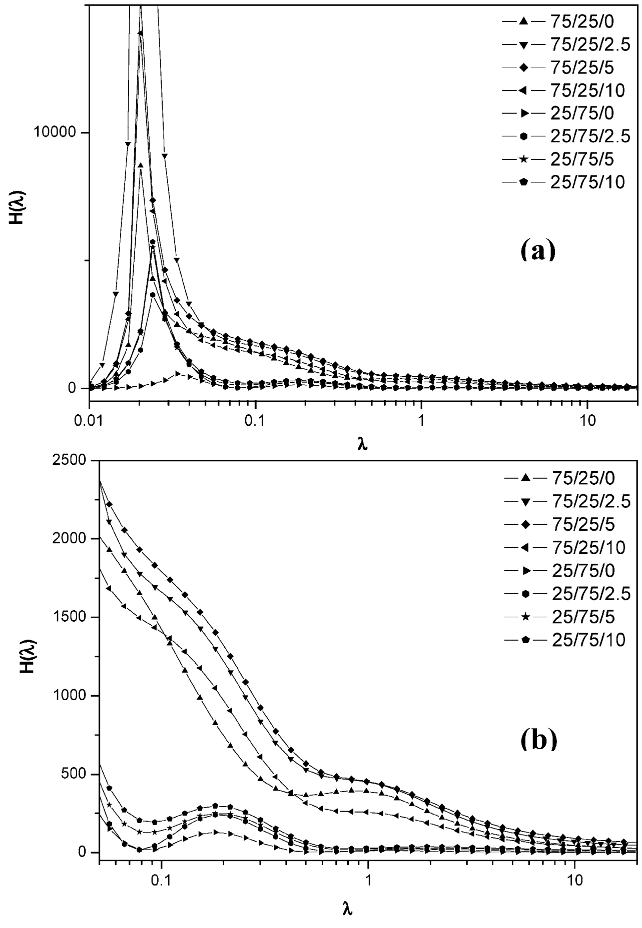
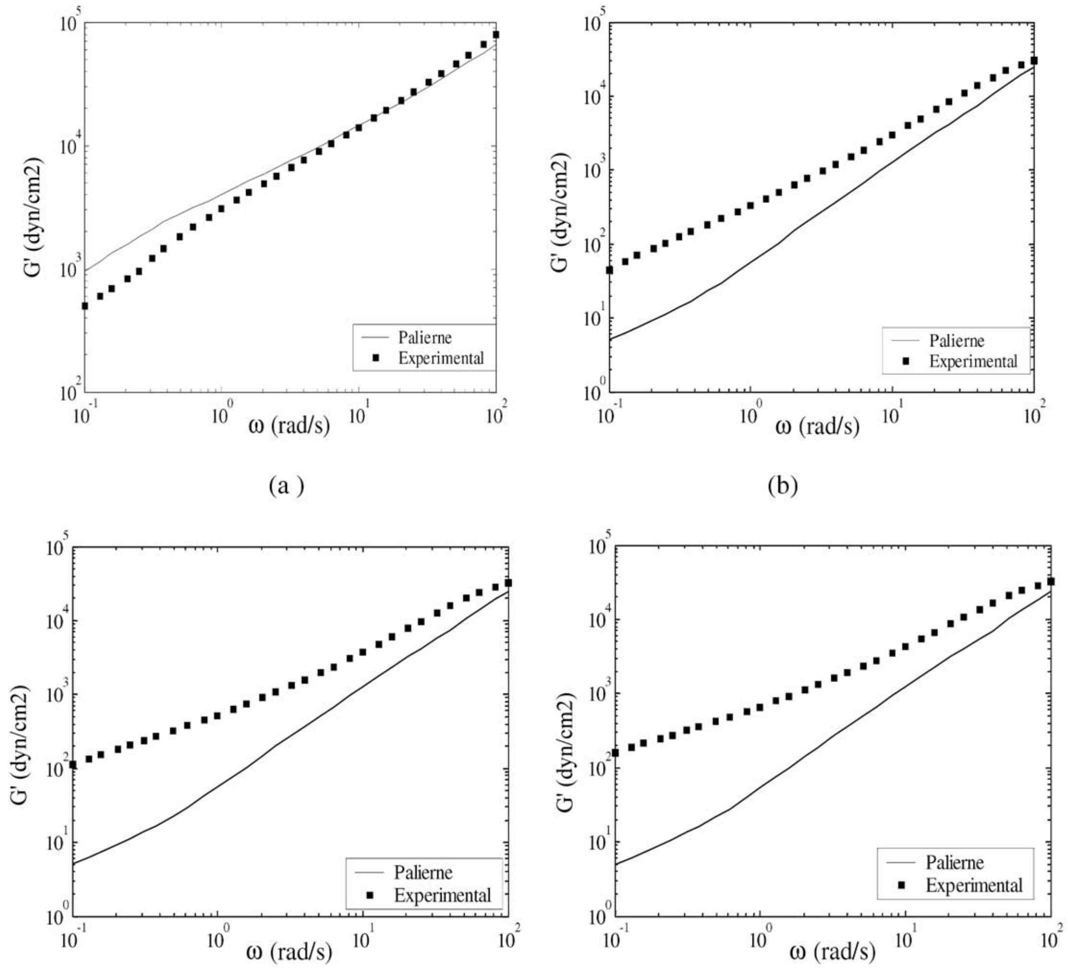


Fig. 8. Relaxation time spectrum of the blends with various amounts of the compatibilizer.

This result is associated with lower solubility of the terpolymer in m-LLDPE than in PTT. The quantitative data obtained from morphological observations of both systems are listed in Table 1. For the system of PTT25/m-LLDPE75 the dispersed droplets are significantly smaller than those of PTT75/m-LLDPE25. An interpretation to this trend is that the dispersed droplets in PTT75/m-LLDPE25 can hardly be broken up to finer particles owing to very high viscosity ratio of the system. The particle size distribution of PTT25/m-LLDPE75 blends is listed in Table 1. It is observed that this distribution becomes narrower due to the addition of compatibilizer up to 2.5 wt%, beyond which the distribution breadth reveals no discernible change. This observation may be attributed to the micellar aggregates formation upon additional increase of compatibilizer content after the compatibilizer saturates the interface.

4.2. Blend rheology

The dynamic rheological response of neat components as a function of angular frequency is shown in Fig. 3. A large difference between the complex viscosities of both components is observed particularly at low frequencies. Moreover, m-LLDPE reveals a stronger dependency on angular frequency. Fig. 4 exhibits the dynamic shear modulus of PTT75/m-LLDPE25 blends with various levels of compatibilizer. The introduction of the terpolymer to the system is found to increase the dynamic shear modulus which is assigned to three reasons. The reasons refer to the role of interfacial agent in reducing the dispersed droplet size and



(a)

(b)

(c)

(d)

Fig. 9. Dynamic storage modulus of PTT 75/m-LLDPE 25 blends with various amounts of compatibilizer as a function of angular frequency: (a) 0 wt%, (b) 2.5 wt%, (c) 5 wt%, (d) 10 wt%.

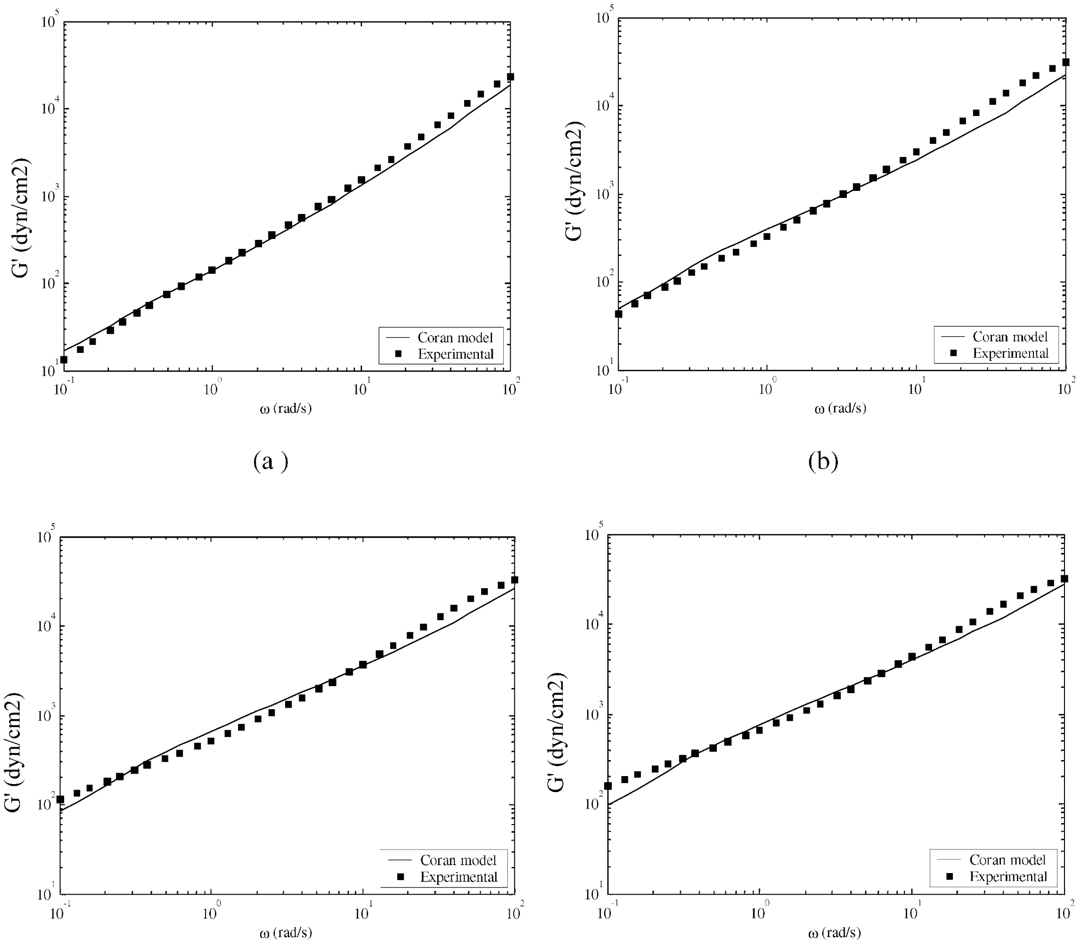
narrowing the particle size distribution as well as inducing an additional contribution to blend shear modulus because of the interactions of terpolymer, at interface, with components. This holds only for the range of 0–5 wt% of compatibilizer beyond which no significant change is revealed originated from the saturation of interface with terpolymer.

The complex viscosity and loss modulus data of the system as indicated in Fig. 5 show the same trend. A good agreement exists between morphological observations and rheological response of the system of interest. Also, one can see that the influence of compatibilizer on the rheological characteristics of the system is more pronounced in lower frequencies. This may be related to this fact that parts of the structures resulted from the interfacial interactions among terpolymer and blend components collapse at higher shear rates leading to reduce the contribution of interface to the blend rheological properties.

The dynamic shear modulus of PTT25/m-LLDPE75 system is illustrated in Fig. 6. One can find three different variation modes upon increasing the amount of compatibilizer. A significant enhancement of modulus is obtained until 2.5 wt% terpolymer, while a slight difference is achieved by adding more compatibilizer up to 5 wt%. Further addition of compatibilizer unexpectedly leads to a sharp decrease in blend modulus. This finding may be

Table 2
Fitting parameters (*f*) for Coran model

System	PTT 75/m-LLDPE 25				PTT 25/m-LLDPE 75			
wt% Compatibilizer	0	2.5	5	10	0	2.5	5	10
f	0.57	0.45	0.34	0.26	0.96	0.95	0.93	0.64



(a)

(b)

(c)

(d)

Fig. 10. Dynamic storage modulus of PTT 25/m-LLDPE 75 blend with various amounts of compatibilizer as a function of angular frequency: (a) 0 wt%, (b) 2.5 wt%, (c) 5 wt%, (d) 10 wt%.

associated with the generation of micelles inside the bulk phase which have a plasticizing action on the modulus of the blend as suggested by Asaletha et al. [56]. Since the terpolymer used has a high molecular weight and copolymer chains with high molecular weight generally prefer to form micelles instead of localizing at the interface, then, this terpolymer exhibits high tendency toward micelle formation. Accordingly, the PTT25/m-LLDPE75 system is believed to form micelles which accounts for the sharp drop of blend shear modulus. The same trend is evident for the complex viscosity and loss modulus of the system as demonstrated in Fig. 7.

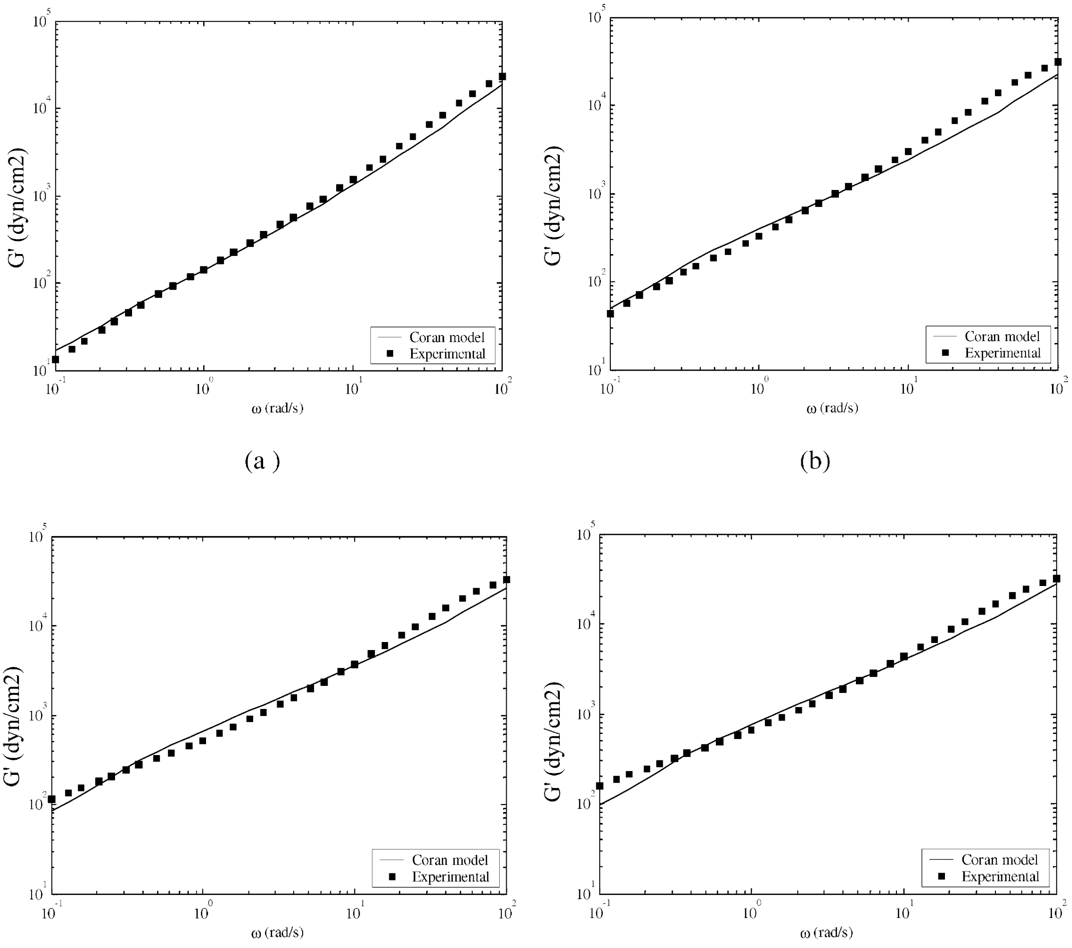
4.3. Relaxation time spectrum

The effects of the compatibilizer on the relaxation time spectrum of the samples are presented in the Fig. 8(a) and (b). The relaxation time spectra have been calculated using a nonlinear regression method from the storage modulus raw data. The Fig. 8(a) shows the relaxation time peaks of both bulk phase and interface and the Fig. 8(b) gives a better insight into the relaxation peaks associated with the interface. The blends with m-LLDPE as the dispersed phase exhibit relaxation peaks with higher magnitude due to higher droplet size with respect to blends with PTT as the dispersed phase. Furthermore, the increasing of the amount of the compatibilizer leads to relaxation peaks with higher magnitude. This is ascribed to the increase of the interfacial area as a result of decreasing the droplet size upon addition of the compatibilizer.

4.4. Palierne analysis

Fig. 9(a)–(d) shows the comparison of the Palierne model predictions with the experimental storage modulus data of PTT75/m-LLDPE25 blends. According to the morphological observations and rheological data, we expect a descending trend for interfacial tension, but neither admissible values nor a reasonable trend for interfacial tension is observed.

This may be because of too large difference between the complex shear modulus of dispersed and matrix phases



(a) (b)

(c) (d)

Fig. 11. Dynamic storage modulus of PTT 75/m-LLDPE 25 blends with various amounts of compatibilizer as a function of angular frequency: (a) 0 wt%, (b) 2.5 wt%, (c) 5 wt%, (d) 10 wt%.

which significantly reduces the contribution of (α/R) to blend complex modulus in the Palierne formula. Consequently the sensitivity of the model toward interfacial tension value is too low to be capable of predicting reasonable estimations for interfacial tension and only very large values of α give the best fit of experimental data to the model. The theoretical results presented in the Fig. 8(a)–(d) correspond to the value of $\alpha = 0.1$ N/m.

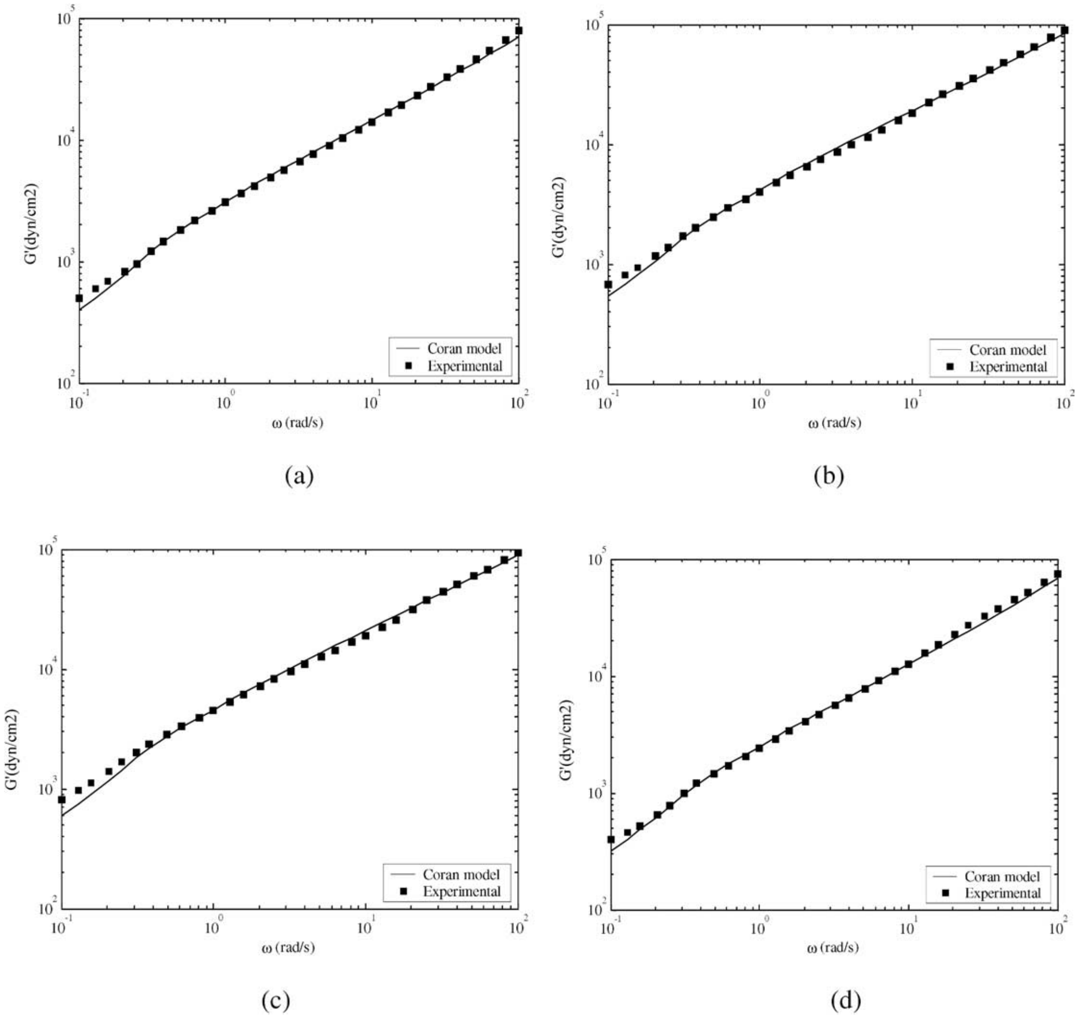
The comparison of the Palierne model predictions with the experimental storage modulus data for PTT25/m-LLDPE75 blends is depicted in Fig. 10(a)–(d). The α values corresponding to the best fit have been calculated. However, no reasonable trend is exhibited by these values as expected from morphology and rheological data. This may also be due to excessively large difference between the complex shear modulus of dispersed and matrix phases leading to decrease the contribution of (α/R) to blend complex modulus in the Palierne formula.

4.5. Coran model

Figs. 11 and 12 show the Coran model predictions of the experimental data for PTT 75/m-LLDPE 25 and PTT 25/m-LLDPE 75 systems, respectively. It can be observed that this model fits well to the experimental data. The values of f (fitting parameter) are given in Table 2.

The values of f for the system in which PTT is the matrix is lower than those in which m-LLDPE is matrix. This is due to lower continuity of the phase with higher viscosity (m-LLDPE phase) in the former system. The low value of the f in the latter system in the presence of 10% compatibilizer is believed to be due to the role of micelles formed in reducing system continuity.

Comparison between the Coran model to that of Palierne shows that Coran model is more appropriate to describe the data and explain the structures obtained here. It is no surprise that the Palierne model cannot describe the data because this model has been derived based on zero-thickness interface, simple viscoelastic component fluids



(a) (b) (c) (d)

Fig. 12. Dynamic storage modulus of PTT 25/m-LLDPE 75 blend with various amounts of compatibilizer as a function of angular frequency: (a) 0 wt%, (b) 2.5 wt%, (c) 5 wt%, (d) 10 wt%.

and the absence of specific interactions between the phases, except the interfacial tension. It essentially describes the extra contribution of the deformation of the elastic interface to the relaxation spectrum of the blend. These requirements are not met by the blend systems used in this work. The presence of the compatibilizer generates an interlayer that has some finite thickness. In reality this is a third phase in the system. As explained earlier, at high compatibilizer contents there may even be another phase, the micelles which may interact with the matrix and add another contribution to the elasticity of the system. The compatibilizer interacts with the components across the interphase and, apparently, it generates a structure, a sort of (physical) intermolecular network which has its own yield stress. This can be seen by the slope of G' of the compatibilizer blends at low frequencies: G' does not reach a terminal region (Fig. 4). After the addition of the compatibilizer, there are interactions between the phases giving contributions to the rheological behavior that go beyond the simple interface and its interfacial tension driven elasticity.

Therefore it is necessary to apply a mechanistic model, where the contributions of each phase (i.e. also of the polymer chains in the interphase region) and the interactions that give rise to the yield stress would be included explicitly. A recent attempt to model thermoplastic elastomers (TPE)/PP and vulcanized EPDM/PP blends showed, indeed, that models based on the idea of a simple contribution of the interface elasticity to the rheology cannot be applied to complicated, rheologically non-simple systems or structures with yield stress [53]. The problem was the network structure that existed in the elastomer phase. This caused the slope of the G' curves of the components and the blends to remain low (close to zero) at low frequencies. In that work a combination of mechanical parallel and series models was used for the moduli with parameters that depended on the morphology which were successful in describing the results.

Although the LLPDE/PTT systems used in this work does not show the characteristics of the thermoplastic elastomers blends, but it also shows an apparent yield stress and interactions between the phases that may lead to the presence of a structure. The Coran model which reflects the morphology, together with the common series and parallel mixing rule approaches seems to be appropriate for applying to the systems used in this work. Hence the Coran model was applied to these blend systems which could well describe the data and the resulting structures. This shows that the contribution of the interface is negligible and the values of the dynamic moduli are determined mostly by the values of the moduli of the components and the morphological structures that form in the blend systems in presence of the compatibilizer. This is equivalent to the presence of relaxation modes with considerable strength at the long relaxation times, at the frequency range where also the contribution of the interface should appear.

5. Conclusions

In this contribution, a systematic study on the PTT/m-LLDPE system in the presence of compatibilizer has been carried out. According to the results, the particle radius in the PTT75/m-LLDPE25 system decreases in proportion to the level of added compatibilizer up to 5 wt% of terpolymer. When the amount of compatibilizer exceeds 5 wt%, the particle size remains unaffected. This is due to saturation of the interface by the compatibilizer that results in a reduction of the compatibilizer efficiency. Furthermore, the complex viscosity of this system enhances upon increasing the level of compatibilizer which is related to the interactions of the terpolymer with blend components. The morphology of PTT25/m-LLDPE75 system shows that the saturation of the interface takes place at 2.5 wt% compatibilizer content. The Rheological examinations show an increase of rheological parameters up to 5 wt% compatibilizer and a marked drop at 10 wt% terpolymer which the latter observation is ascribed to the micelle formation in the bulk phase. Also, the addition of the compatibilizer enhances the magnitude of the relaxation time peaks respective to the interface. The Palierne model was expected to estimate the interfacial tension but it fails to predict admissible values and reasonable trend for interfacial tension believed to be due to the excessively large difference among the complex shear modulus values of the dispersed and matrix phases. However, the Coran model applied in order to describe the dynamic moduli, fits well to the experimental data. This was explained based on interaction of the compatibilizer with the components across the interphase and generation of a sort of physical intermolecular network with its own yield stress.

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