Ternary Blends of Acrylic Rubber, Poly(butylene terephthalate), and Liquid Crystalline Polymer: Influence of Interactions on Thermal and Dynamic Mechanical Properties

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ABSTRACT: The ternary blends of acrylate rubber (ACM), poly(butylene terephthalate) (PBT), and liquid crystalline polymer (LCP) were prepared by varying the amount of LCP but fixing the ratio of ACM and PBT, using melt mixing procedure. The influence of interactions on thermal and dynamic mechanical properties of the blends was investigated over the complete composition range. The techniques applied were Fourier transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), thermogravimetry (TG), and dynamic mechanical analysis (DMA). The FTIR spectroscopy analysis showed reduction in the intensity of the peak corresponding to epoxy groups of ACM with increasing heating time at 290°C. This implies that there is a chemical reaction between the epoxy and end groups of PBT and LCP. Glass transition temperature (T_g) and melting temperature (T_m) of the blends were affected depending on the LCP weight percent in the ACM/PBT blend, respectively. This further suggests the strong interfacial interactions between the blend components. In presence of ACM, the nucleating effect of LCP was more pronounced for the PBT phase. The thermogravimetric study showed improved thermal stability for the blends with the increasing LCP content. © 2006 Wiley Periodicals, Inc. J Appl Polym Sci 100: 3904–3912, 2006

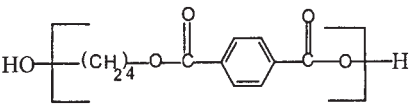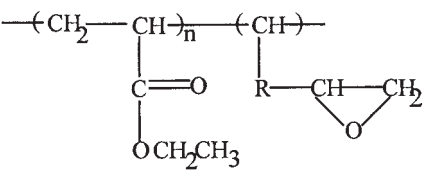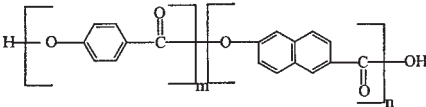**Key words:** liquid crystalline polymers; thermal properties; glass transition; melting point; X-ray

INTRODUCTION

Self-reinforced thermoplastic blends based on thermotropic liquid crystalline polymers (LCPs) and commercial engineering thermoplastics have been studied intensively during recent years. The blends exhibit high strength and modulus, improved temperature and chemical resistance, low coefficient of thermal expansion, and improved barrier properties, and as such are suitable materials for products currently manufactured from pure LCPs. Blending is also considered as a possible route to overcome the highly anisotropic physical properties of LCPs.[1,2] Most of thermoplastics studied thus far are immiscible and incompatible with LCPs.[3–5] Accordingly, the reinforcing effect of LCP is below than that expected from the rule of mixtures. The compatibility of two components in a partially miscible blend is a function of the extent to which the blend properties are altered as compared to a completely immiscible pair. The compatibility can be characterized by a fine dispersion of one phase with in the other, adhesion of the dispersed phase to the matrix, shifting of glass transition temperatures relative to the pure components, reduced interfacial energy between the phases, and molecular interchange.[6] For effective stress transferring from the polymer matrix to LCP fibrils, a strong interfacial adhesion between reinforcing fibrils and the matrix is needed. Blends of immiscible polymers often require the addition of either reactive or nonreactive compatibilizers to improve the dispersion and adhesion of phases, and to stabilize the morphology. Current research on LCP/thermoplastic blends is, indeed, heavily directed toward the addition of a compatibilizer (or coupler) as a means of improving the interaction between blend components. Typically these compatibilizers are functional/reactive polymers or monomers (reactive blending), block or graft copolymers, or polymers with liquid crystalline properties.[7,8] Compatibilization can also be promoted by molecular interchange reactions between blend components, such as *trans*-esterification in ester-containing polymers pairs. It is recognized that the transreaction in polymer blends depends strongly on blending conditions such as temperature, duration of mixing, preparation method, viscosity ratio, and presence of catalysts as well as inhibitors. Li and cowork-

TABLE I
Molecular Structure and Thermal Properties of Polymers

Polymer	Molecular structure	T_g (°C)	T_m (°C)
Poly(butylene terephthalate)	HO—[(CH₂)₄—O—CO—C₆H₄—CO—O]—H	58	229
Acrylic elastomer	—(CH₂—CH)ₙ—(CH)— with C=O, OCH₂CH₃, and R—CH—CH₂ epoxide group	—	—
Liquid crystalline polymer	H—[O—C₆H₄—CO]ₘ—[O—C₁₀H₆—CO]ₙ—OH	103	280

ers[9,10] investigated the miscibility and interfacial adhesion of the LCP/PBT and LCP/polyamide 6, 6 (PA66) blends compounded at 275°C for 5 min. The LCP employed was a semiflexible liquid crystalline copolyesteramide based on 30-mol % *p*-aminobenzoic acid (ABA) and 70-mol % poly(ethylene terepthalate) (PET). They indicated that either *trans*-esterification or *trans*-amidation does not occur in such blends because of the employment of low mixing temperature and short blending time. They concluded that the miscibility of polymer components in LCP/PBT and LCP/PA66 blends owes to the intermolecular interaction, i.e., hydrogen bonding.

Acrylic rubbers and poly(ethylene terephthalate) show excellent resistance to aromatic hydrocarbons, greases, and oils. These are suitable for continuous use at temperatures up to 180°C. The main applications include electrical and automotive industries. Mechanical performance of these polymers can be enhanced by adding fibrous fillers, but presence of solid fibers during processing increases the viscosity of the polymers and produces abrasion of surfaces in the processing equipment. In recent years, thermotropic LCPs have become available and can be processed in the melt to give highly oriented structures that are largely retained on cooling and subsequent crystallization. A similar improvement in the mechanical properties of the polymer can be obtained by blending it with a thermotropic LCP. Highly aromatic ester-based main chain LCPs such as p(HBA/HNA) are useful because of their high strength and modulus, and processability. A limiting factor in the use of these Ar-LCPs with commercially available thermoplastic polymers is their incompatibility, as expressed by poor interfacial adhesion.[11,12] This can be overcome by using a compatibilizer or incorporating a reactive third compo-

nent. In view of the above interest, we report our observation on the blends of acrylate rubber (ACM), poly(butylene terephthalate) (PBT), and Ar-LCP, where the carboxyl end groups of PBT and LCP expected to react with the reactive epoxy groups of ACM to produce necessary graft copolymer at the interface during the melt blending operation. The influence of the interfacial reactions on the thermal and dynamic mechanical properties is highlighted.

EXPERIMENTAL

Materials

Acrylic rubber (ACM) NIPOL AR 51 was obtained from Nippon Zeon Co. Ltd., Tokyo, Japan. It was reported to have an epoxy cure site and made from ethylacrylate monomer. Poly(butylene terephthalate) (PBT) was Valox 325 supplied by GE Plastics, USA. Thermotropic liquid crystalline polymer (TLCP) was Vectra A 950 from Ticona, USA. The LCP has the comonomer composition of 75 mol % of hydroxybenzoic acid (HBA) and 25 mol % of hydroxynaphthoic acid (HNA). Table I shows the molecular structure and properties of the polymers used.

Preparation of samples

Blends were prepared by melt mixing at 290°C using a co-rotating twin-rotor sigma high temperature internal mixer with a rotor speed of 80 r.p.m., the residence time of polymer melt in the mixing chamber is of the order of 2–3 min. (ACM/PBT)/LCP blends with weight ratio 100/0, 75/25, 50/50, 25/75, and 0/100 were prepared. In all the blends, the ACM/PBT ratio (60/40) was kept constant. The blends were molded at
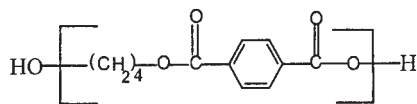
Scheme 1 Reaction mechanism between epoxy groups of ACM and carboxyl end groups of PBT.

Scheme 3 Reaction mechanism between hydroxyl groups of epoxy-*b*-PBT and carboxyl end groups of LCP.

290°C and a pressure of 20 MPa in a compression molding press for 5 min, unless otherwise stated.
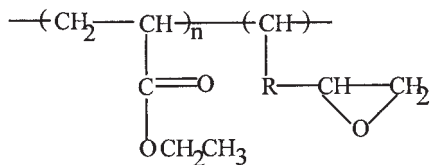
FTIR spectroscopy

Fourier transform infrared spectroscopy (FTIR) experiments were done on ACM, PBT, LCP, and their blends using a NEXUS 870 FTIR (Thermo Nicolet) in humidity less atmosphere at room temperature from 400 to 4000 cm^{-1}. A total of 32 scans were averaged with a resolution of 4 cm^{-1}.

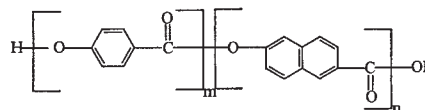### Differential scanning calorimetry

DSC measurements were carried out using a TA Instrument MDSC 2100 model. The samples (10 mg), sealed under aluminum pans were scanned in the temperature range of -50 to 300°C. The heating and cooling rate was 10°C min^{-1} under the nitrogen atmosphere with a flow rate of 40 mL min^{-1}. The percent crystallinity of PBT component is calculated assuming a heat of fusion of 142 J g^{-1} for 100% crystalline PBT.[13] The results reported here was the average of three samples. T_m and ΔH_c can be reproducible within ± 1°C and $\pm 5\%$, respectively.

Dynamic mechanical analysis

Dynamic mechanical properties of the blends were analyzed using a TA Instrument DMA 2980 model in bending single cantilever mode. The samples were subjected to a sinusoidal displacement of 0.1% strain at a frequency of 1 Hz from –50 to 250°C and a heating rate of 10°C min^{-1}. The storage modulus (E′), loss modulus (E″), and loss tangent (tan δ) were measured for each sample in this temperature range.

Scheme 2 Reaction mechanism between epoxy groups of ACM and carboxyl end groups of LCP.

Scanning electron microscopy

Fracture morphology of the blends was studied using a Scanning Electron Microscope (SEM) model JSM-5800 of JEOL Co. instrument. The tensile fractured surfaces of the samples were auto-sputter-coated with gold at 0° tilt angle for the morphological study.

Wide angle X-ray diffraction measurements

X-ray diffraction was performed with a PW 1840 X-ray diffractometer with a copper target (Cu Kα) at a scanning rate of 0.050 2θ/s., chart speed 10 mm/2θ, range 5000 c/s, and a slit of 0.2 mm, applying 40 kV, 20 mA, to asses the change of crystallinity of the blends as a function of blend ratio.

Thermogravimetric analysis

Thermal stability of the blends was studied using a Du Pont TGA-2100 thermogravimetric analyzer in presence of air from 50–700°C, with a heating rate of 10°C min^{-1}.

RESULTS AND DISCUSSION

FTIR study

It is generally known that the epoxy group can react with the hydroxyl (—OH) or carboxyl (—COOH) endgroups of polymers. The acrylate rubber (ACM) used in this study contains epoxy groups as the reactive curing site and therefore, the ACM tends to react with the aliphatic hydroxyl or carboxyl end-groups of PBT and LCP, thereby forming epoxy-*b*-PBT-LCP graft copolymer at the interface during melt mixing. The PBT and LCP employed in this study have end-groups of the carboxyl and hydroxyl form. The reactivity of epoxide with carboxyl is substantially higher than that with hydroxyl, because of the acidity difference.[14] The possible reactions between epoxy and end-groups of PBT and LCP are shown in Scheme 1 and 2 and also the possible reaction between epoxy-*b*-PBT and LCP is shown in Scheme 3. FTIR allows study of molecular interactions in the blend through comparison of the spectra of the blends and those of the component polymers. Normally the spectral differences will be evident as shift in absorption frequencies, band broadening, and changes in band absorptivities. The FTIR spectra of base polymers and (ACM/PBT)/LCP
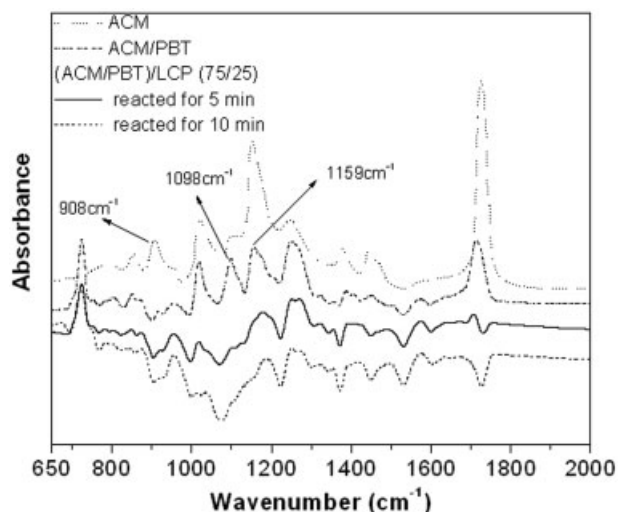
Figure 1 IR spectra of 75/25 weight ratio of (ACM/PBT)/LCP blend reacted for different times.

Figure 2 DSC heating curves of (ACM/PBT)/LCP blends: (a) Pure PBT; (b) 100/0; (c) 75/25; (d) 50/50; (e) 25/75; (f) 0/100 (Pure LCP).

(75/25 w/w) blend reacted at 290°C for 5 and 10 min are shown in Figure 1. It is clear from the figure that the epoxy peak intensity at 908 cm^{-1} decreases progressively with the reaction time. This suggests the reduction of the concentration of epoxy groups of ACM as the reaction proceeds. The C=O absorption band of ACM/PBT blend at 1714 cm^{-1} was affected by the addition of LCP. The C=O peak of the 25 wt % of LCP-containing blend reacted for 5 min shows a broad peak in the range of 1650–1700 cm^{-1}, and on further increasing the reaction time, the peak appeared to become broader and higher in intensity. This shift in the peak position to lower side is reasonable to explain the interactions at the carboxylic end groups of PBT and LCP. The increase in the intensity of the C=O broad peak suggests formation of new ester linkages probably through the chemical reactions, as shown in schemes. The peak at 1098 and 1158 cm^{-1} are due to the asymmetric stretching of C—O—C of PBT and ACM, respectively, decreased in intensity with increasing reaction time. In addition, the IR spectra of 25 wt % LCP blend reacted for 10 min shows a new absorbance at about 1038 cm^{-1}, these may be a consequence of the reactions between the epoxy groups and end groups of LCP and PBT.

Thermal properties

The results of the DSC heating and cooling scans of blends are shown in Figure 2 and 3, respectively, and the corresponding parameters, glass transition temperature (T_g), melting temperature (T_m), crystallization temperature (T_c), heat of crystallization (ΔH_c), and percent crystallinity (X_c) are represented in Table II. To give same thermal history, all the samples were heated up to 290°C and held at this temperature for 10
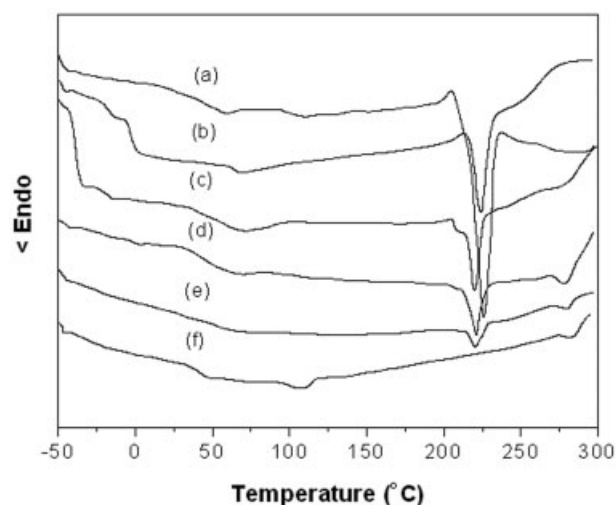
min followed by cooling to room temperature. Figure 2 shows the T_g of pure PBT and LCP at 58 and 103°C, respectively. Blending of ACM with PBT drastically affected the T_g of PBT phase. The T_g of PBT phase in ACM/PBT blend is observed at 69°C. This shift in T_g may be due to chemical reactions such as graft reactions between PBT and ACM. With the addition of 25 wt % of LCP to ACM/PBT, the T_g of ACM and PBT further shifted towards higher temperature side and the T_g of LCP was overlapped with the T_g of PBT, and shows a broad endotherm at about 72°C. This substantiates the compatibility between the blend components. However, the DSC technique did not reveal a clear T_g of the mixed blend at higher level of LCP. This
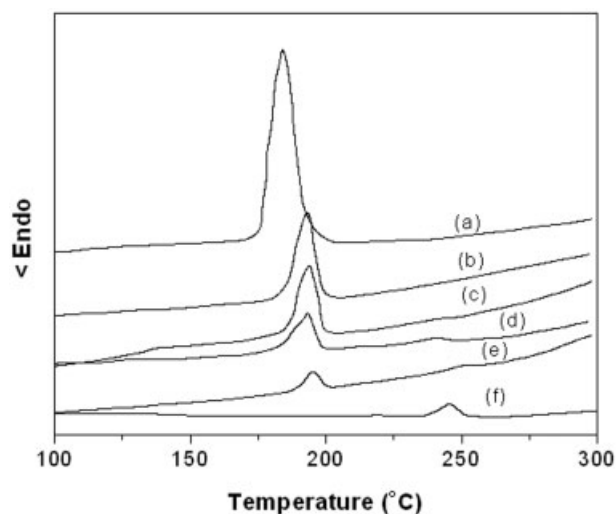

Figure 3 DSC cooling curves of (ACM/PBT)/LCP blends: (a) Pure PBT; (b) 100/0; (c) 75/25; (d) 50/50; (e) 25/75; (f) 0/100 (Pure LCP).

Sample code	Heating			Cooling		
	T_g (°C)[a]	T_g (°C)[b]	T_m (°C)[c]	T_c (°C)[d]	ΔH_c (J g^{-1})[e]	X_c (%)[f]
ACM/PBT (60/40)	−13	69	226	197	17	12
(ACM/PBT)/LCP (75/25)	−12	72	224	198	21	15
(ACM/PBT)/LCP (50/50)	—	72	222	196	20	14
(ACM/PBT)/LCP (25/75)	—	—	222	198	18	13

[a] Glass transition temperature of ACM.
[b] Glass transition temperature of PBT.
[c] Melting peak temperature of PBT.
[d] Crystallization temperature of PBT.
[e] Heat of crystallization (normalized by the PBT content on blend).
[f] Percentage of crystallinity of PBT (normalized by the PBT content on blend).

compatibility may be ascribed to the graft copolymers produced by the reactions between the epoxy groups of ACM and the end groups of PBT and LCP. Formation of such products at the interface may enhance the miscibility of the blend components thereby affecting the T_g of the respective components. Upon increasing the temperature, the heating curve of pure PBT shows an endotherm at 229°C, which is corresponding to the T_m of PBT whereas for the LCP the solid crystal-to-nematic melt transition (K→N) (T_m) is observed at 280°C. The ACM/PBT blend shows a melting endotherm of PBT phase (T_m) at 226°C. Addition of LCP to ACM/PBT, there is hardly a variation of 4°C in the T_m of PBT when compared with PBT in ACM/PBT. Above the 50% of LCP there is no change in the T_m of PBT phase. Our results for thermal behavior are in quite agreement with the Sang results,[15] which showed a lowering of T_m in LCP/PBT blends. Sang believed that the melting point depression of PBT is due to partial diluent effect caused by the LCP. No crystallization-related exothermic peaks were observed up to 200°C for the pure PBT and blends. A small exotherm can be seen near the melting point of PBT, in pure PBT and ACM/PBT blend. The same result has also been observed by Nadkarni et al.[16] With the addition of LCP to ACM/PBT, the minor exotherm disappeared. This can be explained by the fact that the PBT has already reached its highest achievable crystallinity after cooling to low temperatures during molding and no additional crystallization occurs during the DSC heating process. This further confirms by the appearance of new endothermic peak near the melting point of PBT in ternary blends. It is very well documented that the addition of small amount of LCP can significantly enhance the crystallization rate of PBT. PBT has two crystalline structures, α and β forms, which can undergo a reversible transformation at a low level of applied stress.[17] The appearance of two endotherms can be interpreted reasonably as the result of the sequential melting of the two different crystalline structures. The fast crystalli-

zation rate of PBT in presence of LCP could result in a small fraction of less perfect crystallites. The first endotherm could be attributed to the partial melting of these less perfect crystallites at a temperature slightly lower than that of normal crystallites. However, the absence of the first endotherm in pure PBT and ACM/PBT blend does not necessarily mean that the melting of less perfect crystallites does not occur. It may take place but is completely offset by the exothermic peak.

Figure 3 shows the DSC traces of blends when cooled from the melt state. From this figure it is noticed that PBT and LCP crystallize at about 185 and 236°C, respectively. In the blends, the PBT T_c is the dominant factor. Additional crystallization peak corresponding to the T_c of LCP appears only at higher concentrations of LCP. The T_c of PBT is affected significantly by the ACM in ACM/PBT. A similar observation has also been made by Jha et al.[18] in their study on PET/ACM blends, and also they found that a slight improvement in the crystallinity of the PET phase occurs with the addition of ACM. Evidently with the addition of 25 wt % of LCP, the crystallization of the PBT occurred at higher temperatures and further addition of LCP no significant change in T_c of PBT phase is observed. However, all the blends show higher T_c than the T_c of pure PBT, suggesting that there is a nucleating effect of LCP component on PBT crystallization. The increase in crystallinity of PBT blended with amorphous polyarylate (PAr)[19] and liquid crystalline poly(biphenyl-4,4′-ylene sebacate) (PB8)[20] has also been reported, although the authors observed a decline of crystallization temperature after adding the second component. In contrast, Sang and coworkers[15] found that with increasing amounts of LCP, T_m of PBT decreases and its crystallization temperature increases. and they also found that the LCP acts as a nucleating agent for the crystallization of PBT. Pracella and coworkers[21] found that both crystallinity and T_c decreased with increasing amounts of liquid crystalline poly(decamethylene 4,4′-terephthaloyldioxdibenzoate) (HTH10). The crystallizability of LCP/

thermoplastic blends depends on the intrinsic property of thermoplastics, and on the compatibility between the LCP dispersed phase and thermoplastics. Minkova and Magagnini reported that the dispersed LCP (Vectra A) phase play a nucleation role in the poly(ethylene 2,6-naphthalate) (PEN) matrix crystallization under isothermal condition.[22] In this study, the crystallinity (X_c) of the PBT component, as determined from the enthalpies of crystallization of PBT, normalized for fractional content, increased with the addition of LCP. This indicates that in presence of ACM, the LCP enhances the formation and nucleation of PBT crystals. This is another indication of strong interface interactions between the components, which modify crystal perfection and purity.

Dynamic mechanical properties

The loss tangent (tan δ) of base polymers and their blends as a function of temperature is shown in Figure
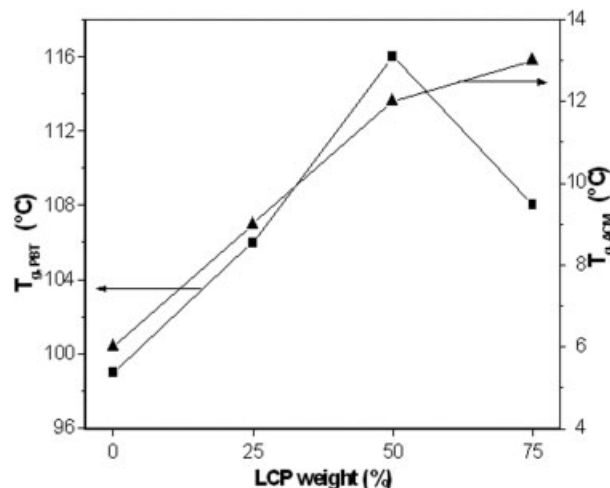
Figure 5 Variation of glass transition temperature of ACM and PBT as a function of LCP weight percent.

4. The T_g is selected as the peak position of the tan δ when plotted against temperature. In Figure 4a, the pure LCP exhibits transition at 123°C. This can be attributed to be T_g of LCP. The T_g value of LCP with the DSC is found at 103°C. This difference in T_g values between the two techniques is caused by the sensitivity towards the glass transition and it is also mentioned in literature.[23] The in situ reactions between the ACM, PBT, and LCP phases, as inferred from the FTIR and thermal analysis, also affected the dynamic mechanical properties of the blends. The ACM/PBT blend shows two transitions, the lower temperature transition corresponding to the T_g of ACM and the other transition at 100°C corresponding to the T_g of PBT phase. Figure 5 shows the variation of T_g of ACM and PBT as a function of LCP weight percent. It shows a gradual shift in the T_g of ACM phase with increasing LCP content and also the T_g corresponding to PBT phase shifted to higher temperature side and overlapped with the T_g of LCP, which (Fig. 4b) shows a single peak in between the T_gs of pure PBT and LCP. This shift in the T_g of ACM and PBT by the addition of LCP is ascribed to the formation of graft block copolymer; formation of such copolymers can reduce the molecular mobility of the polymer chains, and consequently the glass transition occurs relatively at higher temperatures. At higher temperatures such as 200°C, the pure PBT shows one more transition, which is attributed to be the crystallization of PBT, whereas pure LCP shows it about 220°C, which is also reflected in the increase of loss modulus and storage modulus of the samples around 200°C and 220°C, respectively, for the PBT and LCP (Fig. 6 and 7). As expected the 25 wt % LCP-containing blend shows the crystallization of PBT phase relatively at higher temperature. Then again, the blends with the higher percentage of LCP could not show the PBT crystallization transition.
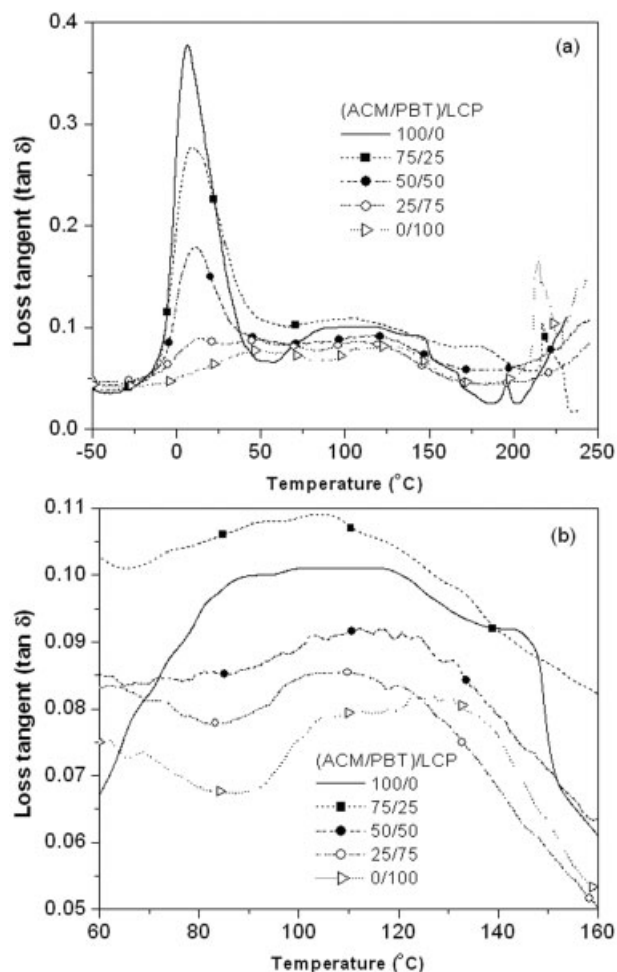

Figure 4 Loss tangent (tan δ) as a function of temperature at 1 Hz frequency: (a) complete temperature range; (b) magnified glass transition temperature region of PBT/LCP mixed phase of ACM/PBT/LCP blends.
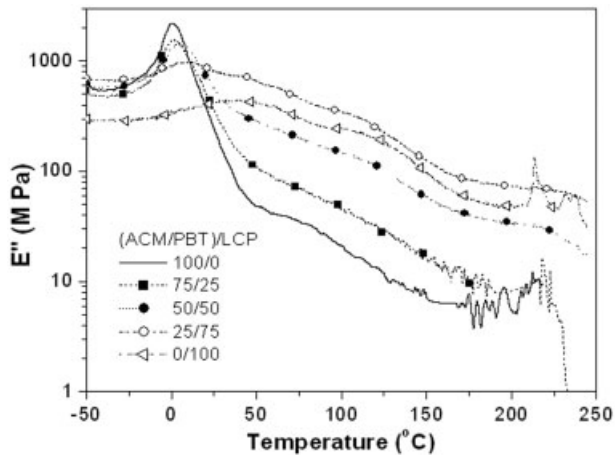
Figure 6 Loss modulus as a function of temperature for PBT/ACM/LCP blends.

These results are in accordance with the studies using DSC. Figure 6 shows variation of storage modulus of the blends as a function of temperature. The storage modulus of the blends increases with increasing LCP content, suggesting that the LCP acts as a reinforcing agent for the ACM/PBT blend. At 75 wt % of LCP, the blend shows higher E' than the pure LCP. This type of improvement in E' is credited to be due to the change in morphology and also to an increase of interaction between the blend components. A similar observation has also made by Weiss et al.,[24] for different pairs of LCP thermoplastics.

Morphology

The dynamic fracture surface of the ternary blends, studied using a scanning electron microscope (SEM), is shown in Figure 8. Figure 8(a) is a micrograph of 25 wt % of LCP-containing blend showing the fibril na-
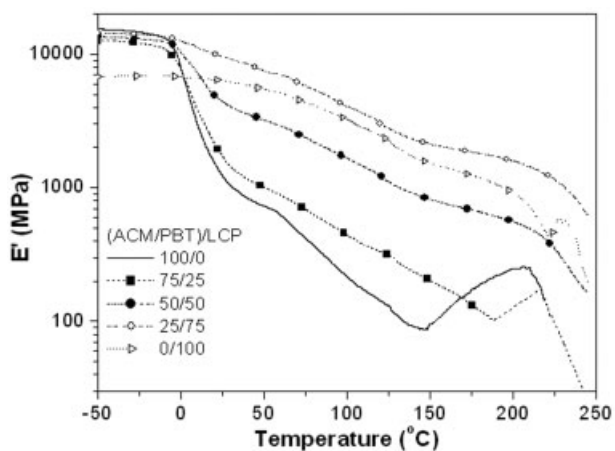

Figure 7 Variation of storage modulus (E') as a function of temperature at 1 Hz frequency.
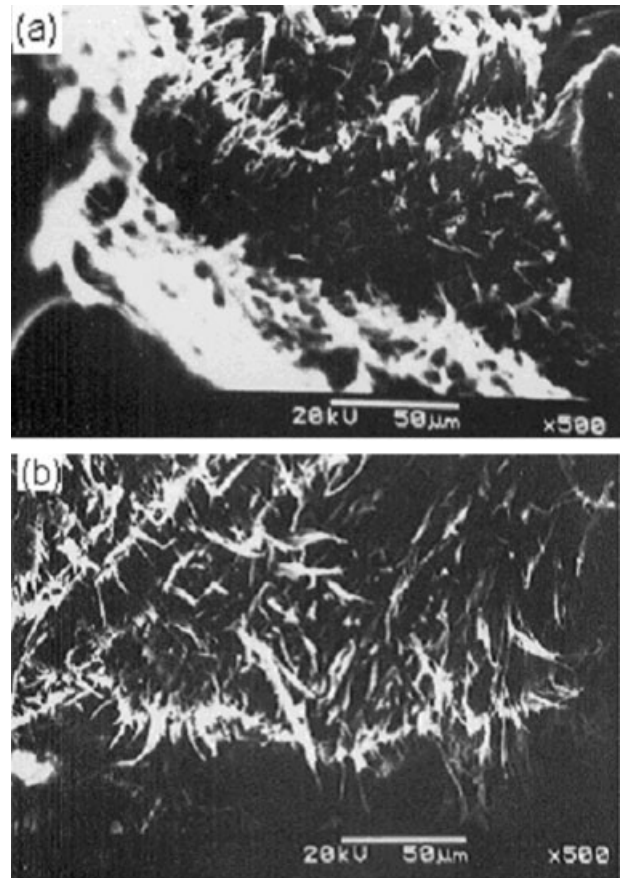

Figure 8 SEM photographs of dynamically fractured (ACM/PBT)/LCP blend surfaces: (a) 75/25; (b) 25/75.

ture of the LCP domains in the predominant ACM/PBT matrix face. These fibrils are very short and stubby. At higher level of LCP (75 wt %), the micrograph [Fig. 8(b)] shows higher number of long and thin fibrils of the LCP domains and also these micrographs show a strong adhesion at the interface between LCP fibrils and ACM/PBT, this suggests that the compatibilized blends lead to a strong adhesion at the interface by forming graft block copolymers. Such copolymer molecules obviously exist in the interfacial region, and contribute significantly to a reduction in the interfacial tension and enhance the adhesion between the phases. This is also reflected in increase in the storage modulus of the blends.

Wide angle X-ray diffraction

Figure 9 shows wide-angle X-ray diffraction patterns of ACM/PBT, LCP, and their blends. The diffractograms of ACM/PBT consist of five peaks, while those of LCP consist of two broad peaks. The diffraction pattern of the blends, whose major phase is PBT, exhibits all the reflection of the PBT component up to 50 wt % of LCP. At higher level of LCP (75 wt %), the peaks of PBT overlap with the broad peak of LCP,
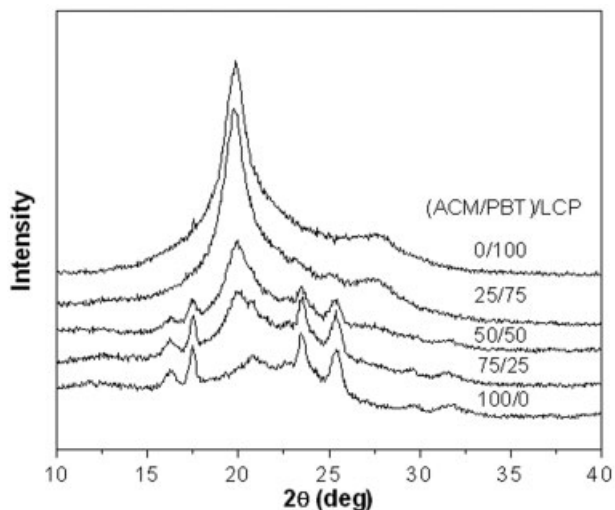
Figure 9 Wide-angle X-ray diffractograms of ACM/PBT/LCP blends.

Figure 11 TG curves of (ACM/PBT)/LCP blends.

showing a single broad peak centered at $2\theta \approx 19°$, which resembles that of pure LCP X-ray pattern. In all the ACM/PBT/LCP blends, the broad peak at about $2\theta \approx 19°$ increased in intensity with increasing LCP content because LCP acts as a reinforcing agent in the blends.[25] The crystallinity of ACM/PBT/LCP blends mainly depends on the PBT and LCP phases. The degree of crystallinity of blends against LCP weight percentage is shown in Figure 9. The degree of relative percentage of crystallinity of the blends was given by the X-ray diffraction method from the following equation.[26]:

$$X\ (\%) = C/A + C \times 100$$

where A is area under the amorphous halo and C is area under the crystalline phase. Figure 10 shows the

maximum percentage of crystallinity at 75 wt % of LCP followed by 25 and 50 wt % of LCP blends. All the LCP-containing blends show higher percentage of crystallinity than does the ACM/PBT blend. This again indicates nucleating behavior of LCP for the PBT phase. However, it is difficult to calculate the crystallinity of the PBT phase alone in the blend using XRD method because of overlap of the respective peaks of PBT and LCP.

Thermal stability

To see the effect of LCP on thermal stability of ACM/PBT, the thermogravimetric (TG) analysis was conducted. The TG curves of the blends of various compositions, obtained at a heating rate of 10°C min^{-1} in air are shown in Figure 11. To avoid any ambiguity, the degradation temperature has been defined as the
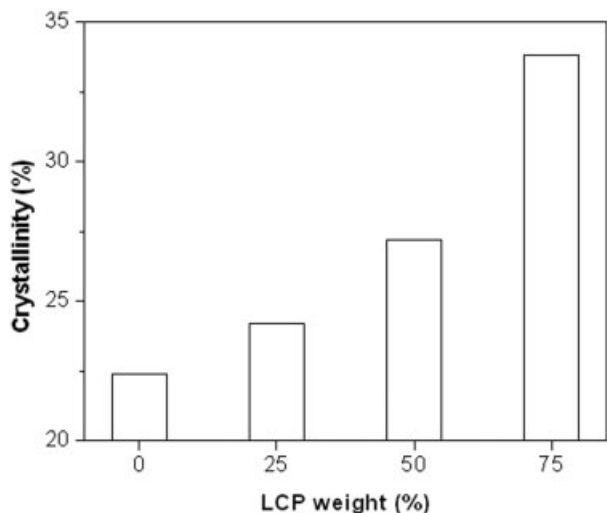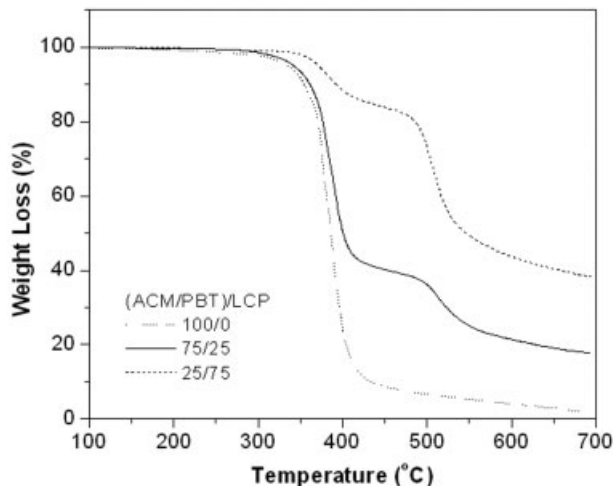

Figure 10 Percentage of crystallinity of ACM/PBT/LCP blends as a function of LCP weight percent.
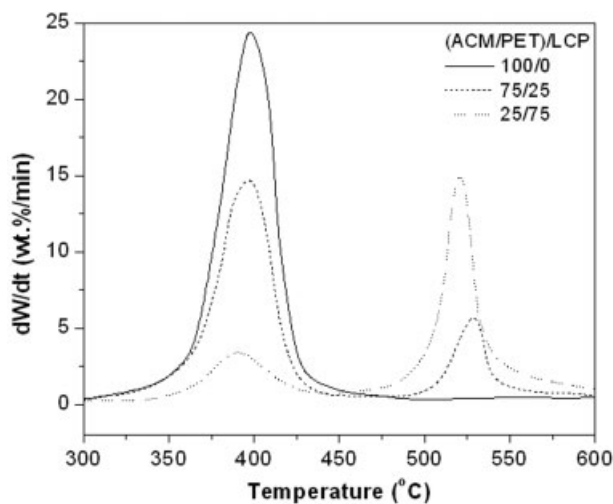

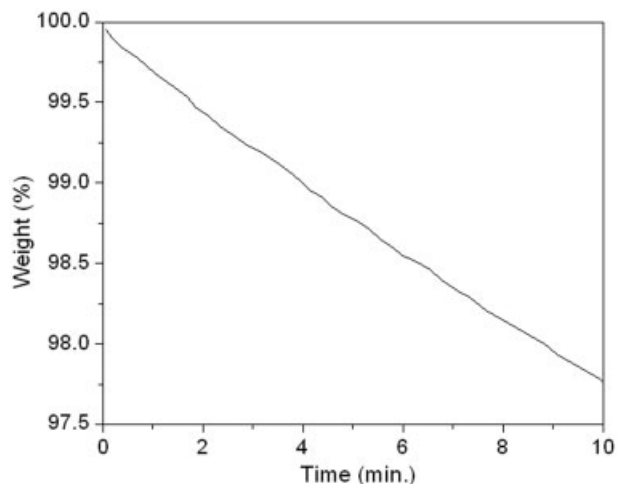**Figure 12** DTG curves of (ACM/PBT)/LCP blends.

Figure 13 TG curve of 25 wt % of LCP blend heated isothermally at 290°C for 10 min.

temperature at which the polymer lost 1% of its weight. From the thermograms it is observed that the ACM/PBT shows one-step degradation at 324°C whereas ACM/PBT/LCP blends show two-step degradation, the second step corresponding to the degradation of LCP. The ACM/PBT undergoes extensive decomposition between 324 and 450°C. This means that ACM/PBT is stable till 324°C, beyond which degradation begins and then intensifies. The thermal stability of the blends remarkably increased with the increasing LCP content. The degradation temperature of ACM/PBT is observed at 332 and 364°C for 25 and 75 wt % of LCP, respectively, such type of improvement in thermal stability of ACM/PBT by the addition of LCP is attributed to the increase in crystallinity with increasing LCP content in the blend, which is also reflected in the derivative thermograms (Fig. 12), which show decreased rate of degradation of ACM/PBT blend with the increasing LCP content. It is known that crystalline polymer is thermally more stable than their amorphous counterpart because of energy input required to overcome both strong intermolecular and intramolecular forces. The improvement in the thermal stability of the blends may also be due to incorporation of high thermal stability aromatic content of LCP phase.

To verify whether there is any weight loss or degradation of the blends during the mixing at 290°C, the 25 wt % of LCP-containing blend was isothermally heated at 290°C for 10 min in the presence of air. The thermogram (Fig. 13) did not suggest a major degradation of the sample. It showed a minor weight loss, which is about 2% after isothermal heating for 10 min. However, the mixing time is of the order of 2–3 min, which means the degradation of the blend components during the mixing is negligible.

CONCLUSIONS

The influence of interaction on the dynamic mechanical and thermal properties of the ternary blends was investigated. The FTIR study revealed strong interactions between the epoxy groups of ACM and the end groups of PBT and LCP. The formed copolymer, at the interface between the blend components, significantly affected the thermal as well as the dynamic mechanical properties of the blends. This further suggests that the blends are compatible. It has been proved that the LCP can act as a better nucleating agent in presence of ACM for the PBT. The T_g and T_m of the PBT phase as well as the T_g of ACM were significantly affected by the LCP depending on the amount of LCP used in the blend. In the presence of ACM, the nucleating effect of LCP was more pronounced for the PBT phase. Thermogravimetric study suggested an improved thermal stability of the ACM/PBT phase with the addition of LCP.

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