Mechanical and Thermal Properties of LDPE-Cellulose Acetate Phthalate Blends—effect of Maleic Anhydride-Grafted LDPE Compatibilizer

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ABSTRACT: Biodegradable blends of LDPE and cellulose acetate phthalate have been prepared. Maleic anhydride-grafted LDPE has been added as a compatibilizer to this blend. The elastic modulus and tensile strength has been considerably improved by adding LDPE-*g*-maleic anhydride compatibilizer. Scanning electron microscope micrographs reflected the observed results for the increase in mechanical properties of the blend. Further blend morphology exhibited a deformed matrix for the compatibilized blends. Thermogravimetric analysis studies showed two-stage degradation for the blends. Differential scanning calorimetry thermograms showed a loss of crystallinity for the LDPE phase. © 2009 Wiley Periodicals, Inc. J Appl Polym Sci 112: 649–659, 2009

Key words: LDPE; CAP; mechanical properties; thermal properties; compatibilizer

INTRODUCTION

The vast amount of plastic waste generated by power sector, packaging industries, etc., pose a serious threat to the environment. Among these waste, polyethylene is a major constituent. Incineration of this waste leads to release of toxins into atmosphere while composting takes a very long time to degrade these polymers. An alternative is to blend these materials with biopolymers to develop useful products such as for packaging or bipod membrane applications. Biomass such as starch, cellulose, cellulose derivatives, lignin, and chitin are under utilized (only 5%). Hence, incorporation of these materials into synthetic polymer like LDPE would serve the twin purposes of developing a cost effective biodegradable polymer (when compared with expensive synthetic biopolymers like Biopol) as well as develop useful products using biomass.

It has been envisaged that cellulose derivatives as opposed to cellulose are more thermoplastic and biodegradable.[1] Hence in this work, the authors attempted to blend LDPE with cellulose acetate phthalate (CAP). However, the adhesion between the nonpolar LDPE and polar CAP is poor leading to inferior mechanical properties.

Similar attempts to blend cellulose acetate with polyacrylonitrile (PAN) have been made by Kim et al.[2] It was observed that modification of PAN with an acid group improves the homogeneity of the blend. CAP films have also been tested for water vapor permeability by Fakhouri et al.[3] However, addition of wheat gluten to CAP reduced the mechanical strength of the composite film. Thermodynamic studies by Silva et al.[4] predicted the possibility of obtaining controlled morphologies for CA-polystyrene immiscible blend cast in a common solvent. Grafting of synthetic polymer like MMA onto CA was found to improve thermal and mechanical properties.[5] An improvement in mechanical properties was obtained by addition of sisal fiber to cellulose ester/starch without undergoing significant thermal degradation of the blend.[6]

However, there are no studies of CAP blends with LDPE so far. In this work, the thermal and mechanical properties of LDPE/CAP blends have been studied. The effect of adding LDPE-*g*-maleic anhydride (PEMAH) as compatibilizer in the blend has been examined.

EXPERIMENTAL

LDPE (Grade 24 FSO40 and melt flow index of 4 g (10 min⁻¹) from IPCL, Vadodara, India) was used. Cellulose acetate was purchased from Sigma Aldrich. Maleic anhydride and other common solvents were obtained from S.d. fine Chem. Mumbai.

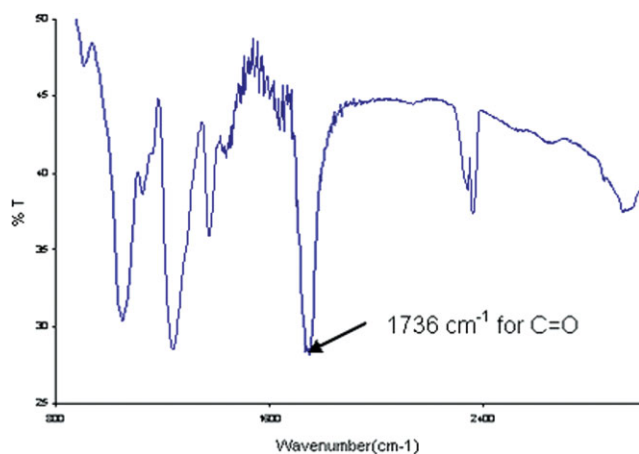*Correspondence to:* R. R. N. Sailaja (rrnsb19@rediffmail.com).

Figure 1 FTIR of cellulose acetate phthalate(CAP). [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Synthesis of CAP

CAP was synthesized as per the procedure described in reference.[7] 50 g of cellulose acetate was immersed in 250 mL of acetone for 24 h at room temperature for swelling. To this was added 75 g of phthalic anhydride and 1.2 mL of oleum. Triethylamine (64 mL) was added drop wise to the mixture under continuous vigorous stirring. The reaction was refluxed for 4 h. The product was precipitated in ethanol and rinsed repeatedly in fresh ethanol. The FITR spectra of CAP (Fig. 1) shows the characteristic bond at 1736 cm^{-1} for $-C=O-$ group.

Synthesis of compatibilizer

LDPE-g-maleic anhydride compatibilizer has been synthesized as described earlier.[8] 5 g of LDPE was added to boiling toluene under reflux along with an equal amount of maleic anhydride. Benzoyl peroxide initiator (0.15 g) was added to this solution. The refluxing was continued for 4 h. The cooled solution was slowly precipitated in methanol. The unreacted maleic anhydride was removed by repeatedly rinsing the grafted polymer with fresh methanol. The grafted polymer was further washed with acetone and dried. The dried polymer was finely powdered in a ball mill. The grafting percentage was determined as described by Gaylord et al.[9] and this was found to be 3.2% (w/w).

Melt blending

Blends of LDPE, CAP, LDPE-g-maleic anhydride, and 0.1% iron stearate autooxidant were melt mixed in varying proportions at 210°C in a heated cup fitted with a spiked motor. Dumb-bell shaped specimens were then molded into standard dies with Minimax molder (Custom Scientific Instruments,

New Jersey, Model CS-183MMX). The amount of compatibilizer was based on weight percent of CAP throughout the study.

Mechanical properties of the blend

A Minimax impact (Model CS-183T1079) and tensile tester (model CS-183TTE) (custom Scientific Instruments, NJ) was used to measure impact strength and tensile properties, respectively. At least eight specimens were tested for each variation in the composition of the blend. The impact and tensile tests were performed as per ASTM D1822 and ASTM D1708 methods, respectively.

Thermal analysis

Thermogravimetric analysis (TGA) was carried out for the blends using Perkin–Elmer Pyris Diamond 6000 analyzer in nitrogen atmosphere. The sample was subjected to a heating rate of 10°C/min in the heating range of 40–600°C using Al_2O_3 as the reference material.

Blend morphology

Scanning electron microscope (SEM) (JEOL, JSM-840 A microscope) was used to study the morphology of fractured and unfractured specimens. The specimens were gold sputtered before microcopy (JEOL, SM-1100E). The morphology of the unfractured blend specimens was taken after soaking the samples for 2 h in sulfuric acid at room temperature.

RESULTS AND DISCUSSION

LDPE has blended with CAP using PEMAH as compatibilizer. The mechanical and thermal properties have been investigated for these blends.

Relative impact strength (RIS)

The relative impact strength (impact strength of the blend/impact strength of neat LDPE) of LDPE-CAP blends have been examined as shown in Figure 2. In this figure, a plot of RIS versus percentage compatibilizer has been plotted. The RIS values decrease as CAP loading increases from 20 to 40%. Addition of 3% PEMAH to the blend containing 20% CAP considerably improves the impact strength to 85.4% of neat LDPE. A similar observation has been made for 30 and 40% CAP loading. For 30% CAP loading, compatibilization increases the RIS value to around 0.8. However for 40% CAP loading, addition of compatibilizer improves the impact strength by only 15% when compared with the impact strength value for the blend without compatibilizer.
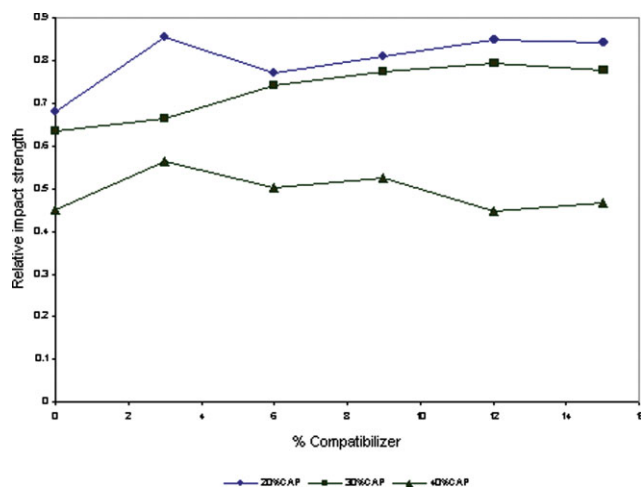
Figure 2 Plot of RIS versus percentage compatibilizer for LDPE/CAP blends. [Color figure can be viewed in the online issue, which is available at www.interscience. wiley.com.]

A statistical analysis for the response (relative impact strength) and its dependence on he two parameters namely, CAP loading (x) and compatibilizer content (y) has been found using Sigma plot^{TM} (version 2). The equation for the RIS are given in Table I. The values of the constants, $\langle r^2 \rangle$ and the standard error of estimate are given in Table II. The $\langle r^2 \rangle$ is 0.934, which indicates that the equation has a good fit with the experimental results.

Figure 3 shows the impact fracture morphology of CAP/LDPE blends. Figure 3(a) shows the impact fracture micrograph of the uncompatibilized blend with 20% CAP loading. The matrix has undergone extensive shearing and cavitation with large holes left by the agglomerated CAP particles. The compatibilized blend for the same CAP loading [Fig. 3(b)] shows extensive shearing and smaller holes left by CAP particles during fracture. For higher, that is, 40% CAP loading (no compatibilizer), it exhibits brittle fracture and large areas of agglomerated CAP particles [Fig. 3(c)]. It appears that the matrix is unable to withstand such high loading. Figure 3(d) is the compatibilized counterpart for 40% loading. The morphology shows much smaller holes with fine dimpled surface spread over the entire fracture area. This is also reflected in the impact fracture values.

TABLE I
Statistical Equations for the Mechanical Properties of LDPE/CAP Blends

RYM	$a_0 + ax + by + cx^2 + dy^2 + exy$; $r^2 = 0.970$
RTS	$a_0 + ax + by + cx^2 + dy^2 + ex^3 + fy^3 + gxy$; $r^2 = 0.890$
RIS	$a_0 + ax + by + cx^2 + dy^2 + exy$; $r^2 = 0.934$
REB	$a_0 + ax + by + cx^2 + dy^2 + exy$; $r^2 = 0.882$

Stress–strain curves

The engineering stress–strain curves for CAP/LDPE blends are shown in Figure 4. For 20% CAP loading (no compatibilizer), the curve is typical of stress yielding exhibiting good ductility (curve (b). Addition of compatibilizer of the blend (curve (c) shows yielding at a higher stress value when compared with the uncompatibilized blend. However for higher CAP loading of 40%, the stress–strain curve exhibits (curve(d) the behavior of a typical brittle material. The compatibilized blend (curve (e), however, shows higher stress value due to improved stress transfer from matrix to filler.

Relative tensile strength (RTS)

Figure 5(a–c) shows a plot of relative tensile strength versus percentage compatibilizer for 20–40% CAP loading. The RTS value decreases by the addition of CAP to LDPE. For every 10% increase in CAP loading, the tensile strength reduces and is only 45% of that neat LDPE for 40% CAP loading. This may be due to the discontinuity caused by the incorporation of CAP particles. The compatibilization of blends improves the tensile strength to more than 80% of that of neat LDPE even with 40% CAP loading.

Figure 5(a–c) shows an optimum (at 12% compatibilizer) tensile strength. Further addition of compatibilizer has a detrimental effect on the tensile strength of the blend. This may be due to saturation of reactive interfacial sites and excess compatibilizer stays back in one of the phases and system behaves like a ternary blend rather than a compatibilized binary blend.

The cubic equation for RTS fitted using Sigma plot software (Table I) shows an $\langle r^2 \rangle$ value of 0.890, which indicates a very good fit with experimental results. The values of the coefficients for the equation are given in Table II.

TABLE II
Numerical Values of Coefficients for the Equations in Table I

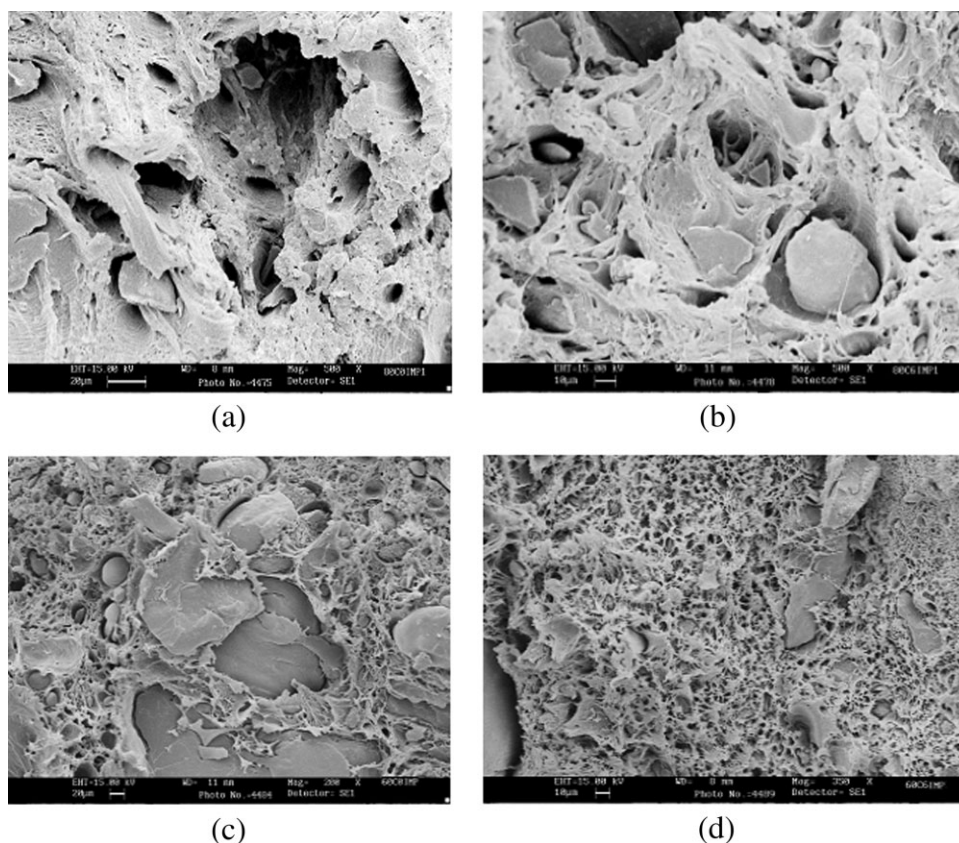| Property	a_0	a	b	c	d	e	f	g	$\langle r^2 \rangle$	Std error of estimate
RYM	1.1266	−0.0042	0.0115	0.0006	0.0001	−0.0017	–	–	0.970	0.0575
RTS	0.5884	0.0089	−0.0083	−0.0003	0.0036	0.0001	0.0002	0.0006	0.890	0.0411
RIS	0.2544	0.0388	0.0347	−0.0008	−0.0009	−0.0005	–	–	0.934	0.0464
REB	0.3003	0.0257	−0.0062	−0.0007	−0.0005	0.0009	–	–	0.882	0.0521

Figure 3 SEM micrographs of impact fractured samples. (a) is for 20% CAP loading (0% Compatibilizer), (b) is for 20% CAP loading (6% Compatibilizer), (c) is for 40% CAP loading (0% Compatibilizer), and (d) is for 40% CAP loading (6% Compatibilizer).

Further analysis of the experimental results obtained has been done using theoretical models. The Nicolais and Narkis model[10] discusses the reduction in effective cross-sectional area caused by the addition of filler particles. The model equation is given below.

$$\frac{\sigma_b}{\sigma_0} = \text{RTS} = (1 - 1.21 \ \phi_f^{2/3}) \tag{1}$$

where, σ_b and σ_o are tensile strength values for the blend and pure LDPE, respectively. ϕ_f is the volume fraction of the filler, which is calculated from the weight fraction by using the following relation.

$$\phi_i = \frac{W_i/\rho_i}{\sum W_i/\rho_i} \tag{2}$$

In the above equation, W_i and ρ_I are the weight fraction and density of component in the blend. Density values are 0.26 g/cm^3 for CAP and 0.92 g/cm^3 for LDPE and 0.91 for compatibilizer. The model assumes no adhesion between the filler and matrix. The uncompatbilized blends show values lower than the model results as shown in Figure 5(a–c). The compatibilized blend (>6% compati-

bilzer) shows higher results than the predicted values indicating better adhesion.

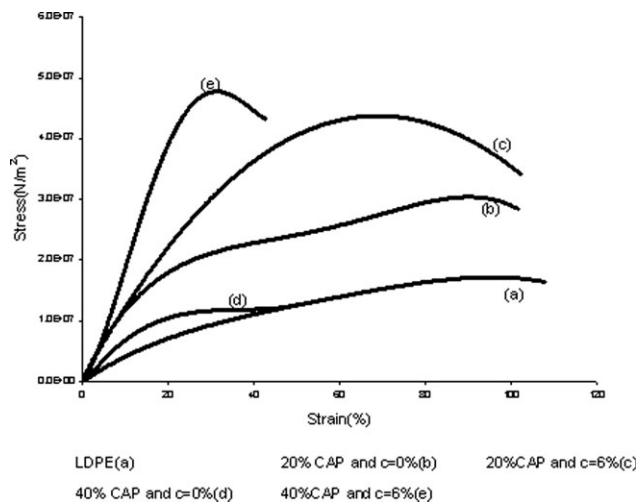The other widely used model is the Halpin-Tsai model,[10] which is as follows

LDPE(a)   20% CAP and c=0%(b)   20%CAP and c=6%(c)

40% CAP and c=0%(d)   40%CAP and c=6%(e)

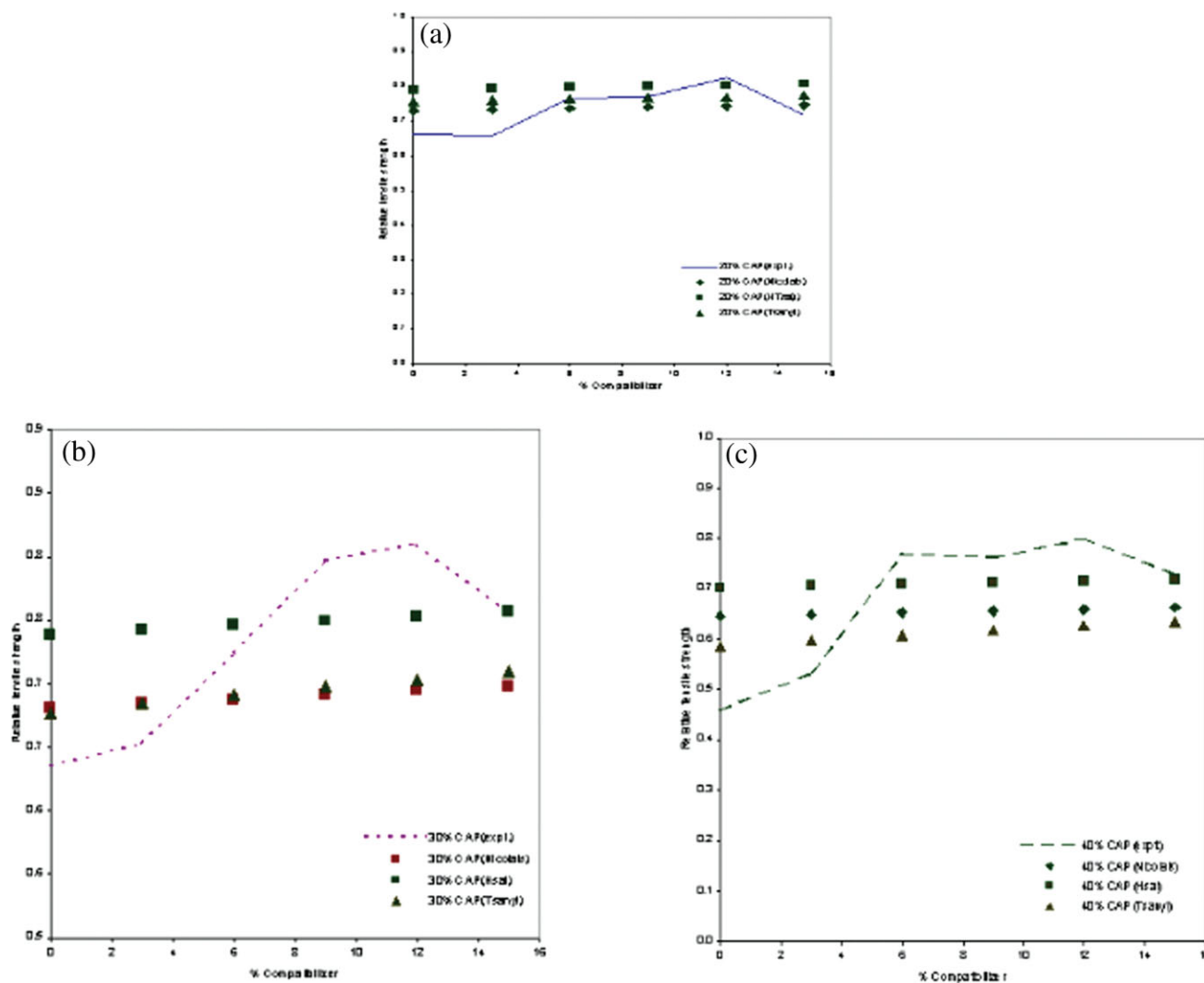**Figure 4** Engineering stress–strain curves for LDPE/CAP blends.

Figure 5 Plot of RTS versus percentage compatibilizer: (a) 20% CAP loading, (b) 30% CAP loading, and (c) 40% CAP loading.

$$\text{RTS} = \frac{\sigma_b}{\sigma_o} = \frac{1 + G\eta_T\phi_f}{1 - \eta_T\phi_f} \quad (3)$$

$$G = \frac{7 - 5\upsilon}{8 - 10\upsilon} \quad (4)$$

$$\eta_T = \frac{R_T - 1}{R_T + G} \quad (5)$$

In eq. (4), υ is Poisson ratio for neat LDPE and is taken to be 0.43.[10] In eq. (5), R_T is the ratio of tensile strength of the filler to matrix tensile strength and this is found out by trial and error. The R_T has thus been found to be 0.6. The Halpin-tsai model assumes good adhesion between the filler and matrix. This model could be fitted closely with the obtained experimental values. For 20% CAP loading [Fig. 5(a)], the deviation is negative for uncompatibilized

blends and this deviation increases as CAP loading is increased to 30% [Fig. 5(b)] and 40% [Fig. 5(c)] for uncompatibilized blends. The model values come closer to the experimental values by addition of compatibilizer. The improvement in adhesion may be attributed to the reaction between hydroxyl and ester groups of CAP with the carboxyl group of PEMAH compatbilizer. The possible reaction scheme is given in Figure 6.

The composition dependence of tensile strength is explained by the empirical model suggested by Bliznakov et al.[11] as given below.

$$\frac{\sigma_b}{\sigma_o} = \frac{1 - \phi_f}{1 + 2.5\phi_f} \exp(B\phi_f) \quad (6)$$

In eq. (6), B is the dependent on interfacial properties. The value of B found by trial and error to match with the experimental values has been found
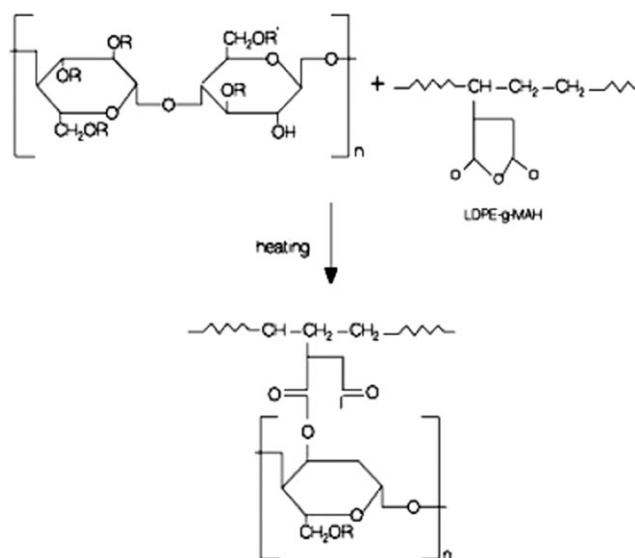
Figure 6 Possible reaction scheme between compatibilizer and CAP.

to 2.4 for the CAP/LDPE blends. It has been observed by Bliznakov et al.[11] that B is around 0.25 for no-adhesion case and its value increases as adhesion is improved. Figure 5(a–c) shows the simulated results obtained for the above model. There is close

fit with the experimental results for 20% CAP loading [Fig. 5(a)]. The predicted results for this model are higher than those predicted by Nicolais and Narkis model but lower than those estimated by Halpin-Tsai model. For 30 and 40% CAP loading [Fig. 5(b,c)], the Halpin-Tsai model predicts higher values than the other two models.

The tensile fracture morphology for CAP/LDPE blends are shown in Figure 7(a) shows the tensile fracture micrograph for uncompatibilized blends with 20% CAP loading. The micrograph is typical of mode A type of ductile fracture with highly drawn fibril bundles[12] combined with cavitations as shown by small holes and protruded voids left by debonded filler particles. The compatibilized blend [Fig. 7(b)] also shows the typical ductile fracture morphology[12] characteristic of rosette formation with pull out regions accompanied by cavitations. This is also reflected in the tensile strength values for 20% CAP loading. The ductile fracture as in Figure 7(a) suggests that the matrix is able to withstand stress upto 20% filler loading. For 40% CAP loading (no compatibilizer), the fractograph shows a quasi-brittle fracture [Fig. 7(c)]. The matrix has undergone extensive shearing and cavitations of agglomerated filler particles in also seen. The
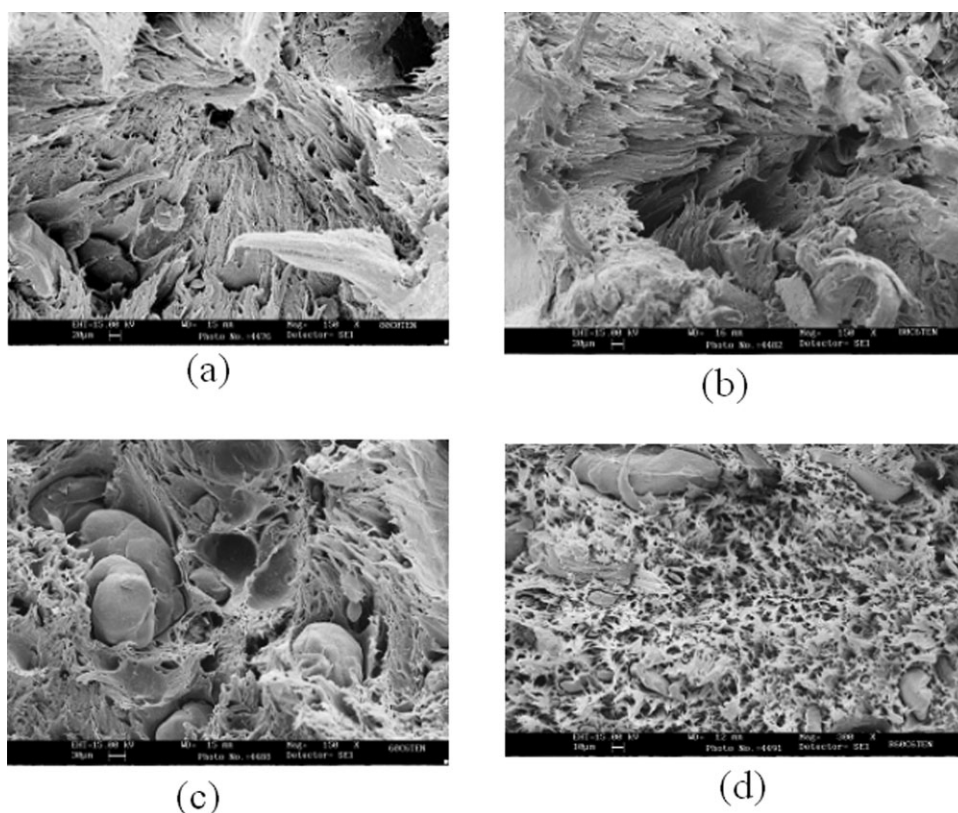

Figure 7 SEM micrographs for tensile fractured samples. (a) is for 20% CAP loading (0% compatibilizer), (b) is for 20% CAP loading (6% compatibilizer), (c) is for 40% CAP loading (0% compatibilizer), and (d) is for 40% CAP loading (6% compatibilizer).
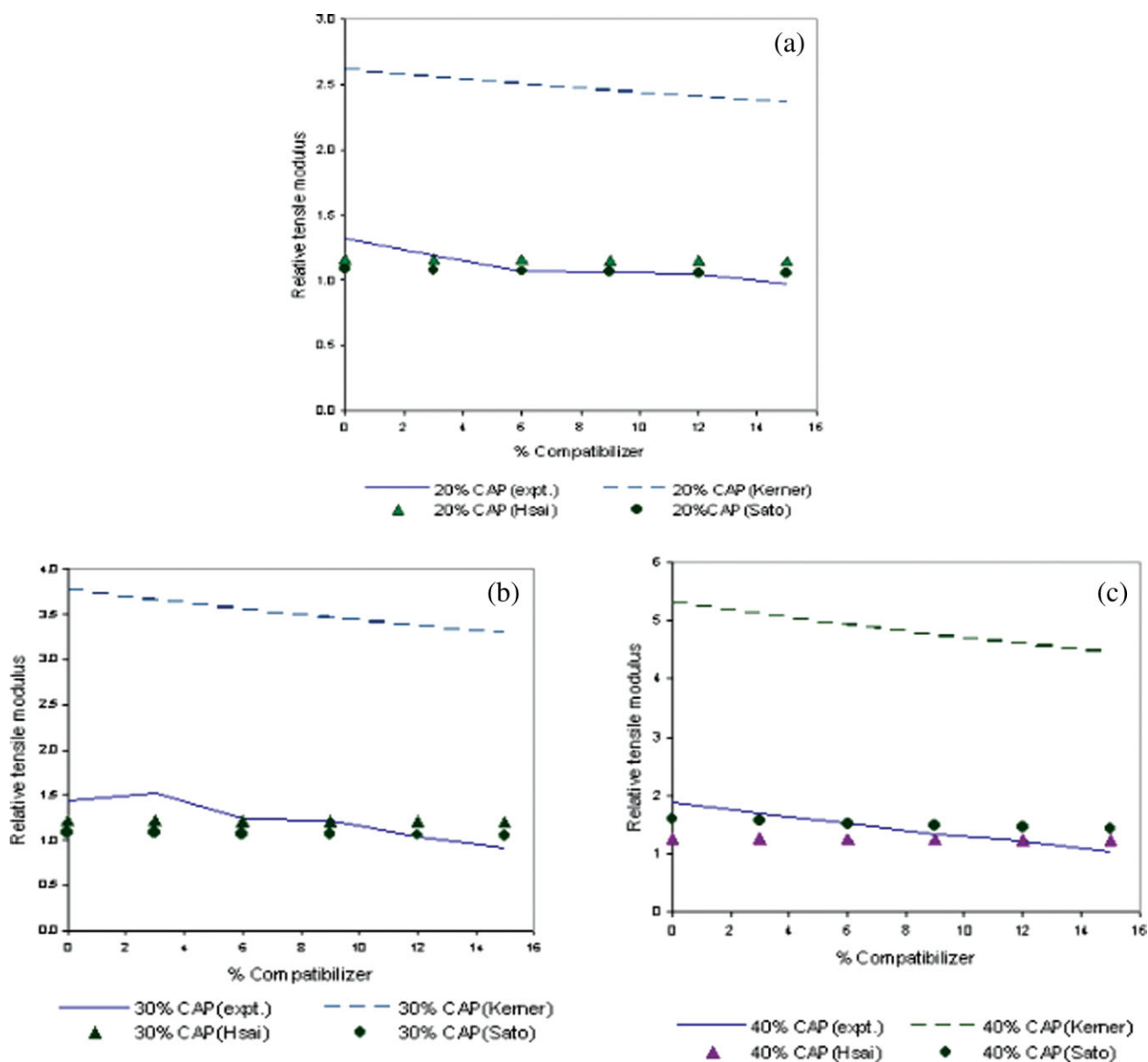
Figure 8 Plot of RYM versus percentage compatibilizer: (a) 20% CAP loading, (b) 30% CAP loading, and (c) 40% CAP loading. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

compatibilized blend fractograph [Fig. 7(d)] shows a dimpled network over the entire fracture area. Shearing and cavitations absorbs large amounts of energy and this are exhibited as high tensile strength. This type of fracture is typical of mode D type of quasi-brittle fracture as suggested by Li et al.[12]

Relative Young's modulus (RYM)

Figure 8(a–c) shows the relative tensile modulus versus percentage compatibilizer for CAP/LDPE blends. The RYM values for uncompatiblized blends are higher than neat LDPE. The incorporation of CAP restricts the mobility of polyethylene chains,

thereby creating a stiffening effect. The compatibilization of these blends improves the adhesion between filler and matrix thereby enhancing the flexibility of the blend. Hence, all compatibilized (i.e., blends with 9–15% compatibilizer) blends exhibit an RYM values close to 1.0, that is, close to that of neat LDPE. The quadratic equation fitting the experimental results for RYM were determined by using the sigma plot software and the corresponding coefficients are given, respectively, in Tables I and II. The $\langle r^2 \rangle$ value of 0.970 suggests a good fit with experimental results.

Three theoretical models have been discussed for further analysis of the experimental results. The first is the Kerner's model[10] as given below.

$$\text{RYM} = \frac{E_b}{E_o} = \left[1 + \left(\frac{\phi_f}{1 - \phi_f} \right) \left(\frac{15(1 - \upsilon)}{(8 - 10\upsilon)} \right) \right] \quad (7)$$

In eq. (7), E_b and E_o are the Young's modulus of the blend and that of pure LDPE, respectively. The theoretical values calculated do not match with the experimental results as shown in the Figure 8(a–c). The model assumes no adhesion between matrix and filler, which suggest that some adhesion exists between filler, and matrix exists even without compatibilization.

The other theoretical model is that of Halpin-Tsai for good matrix filler adhesion is as follows.

$$\text{RYM} = \frac{E_b}{E_o} = \left[\frac{1 + G\eta_m \phi_f}{1 - \eta_m \phi_f} \right] \quad (8)$$

$$\eta_m = \frac{R_m - 1}{R_m + G} \quad (9)$$

In eq. (9), R_m is the ratio of filler modulus to matrix modulus. The R_m value has been found by trial and error to be 1.4 so that the calculated values from eq. (9) match closely with the experimentally observed values. The predicted results from the Halpin-Tsai model are also shown in Figure 8(a–c). The modulus values uncompatibilized blends do not match with the experimental values owing to weak adhesion. However, the compatiblilized blends show a good fit with the experimental results. The PEMAH compatibilizer undergoes reactive compatibilization with CAP to improve adhesion between LDPE and CAP. Further earlier work done by one of the authors[13] on LDPE-starch ester blends also showed a similar trend. As the size of the ester group increases, the processability and thremoplasticity improves. It was argued that the ester groups act as internal plasticizer, thereby improving the processability of the blend.

Sato and Furukawa model[11] formulated a model by incorporating adhesion parameters as given below.

$$\frac{E}{E_o} = \text{RYM}$$

$$= \left[\left(1 + \frac{\phi_f^{2/3}}{2 - 2\phi_f^{1/3}} \right) (1 - \psi Z) - \frac{\phi_f^{2/3} \psi Z}{(1 - \phi_f^{1/3})\phi_f} \right] \quad (10)$$

$$\psi = \left(\frac{\phi_f}{3} \right) \left(\frac{1 + \phi_f^{1/3} - \phi_f^{2/3}}{1 - \phi_f^{1/3} + \phi_f^{2/3}} \right) \quad (11)$$

The values are calculated using eq. (10) and then compared with the experimental values. The factor

Z is an adjustable parameter, which can be varied so that the theoretical values match with the experimental values.

In eq. (10), the scale of Z varies from 0 to 1 for perfect adhesion to no adhesion, respectively. The z value for CAP/LDPE blends has been found to be 0.7 by trial and error to match with the experimental results. Thus, the Z value suggests good adhesion, as perfect adhesion for immiscible blends is impossible.

Relative elongation at break (REB)

Figure 9 shows plot of the relative elongation at break versus percentage compatibilizer for CAP/LDPE blends. The REB values decrease to near half the value of that neat LDPE for 20 and 30% CAP loading. For still higher, that is, 40% CAP loading, the REB value drops drastically to around 25% of that of neat LDPE. For 20 and 30% CAP loading elongation at break attains to the value of ∼ 65% of that of neat LDPE with 12% compatibilizer. For 40% CAP loading, there is a considerable increase in REB value of 0.25 (no compatibilizer) to 0.60 (with 12% compatibilizer).

The Nielson model[14] for perfect adhesion is given below.

$$\text{REB} = \frac{\varepsilon_b}{\varepsilon_o} = (1 - k\phi^{1/3}) \quad (12)$$
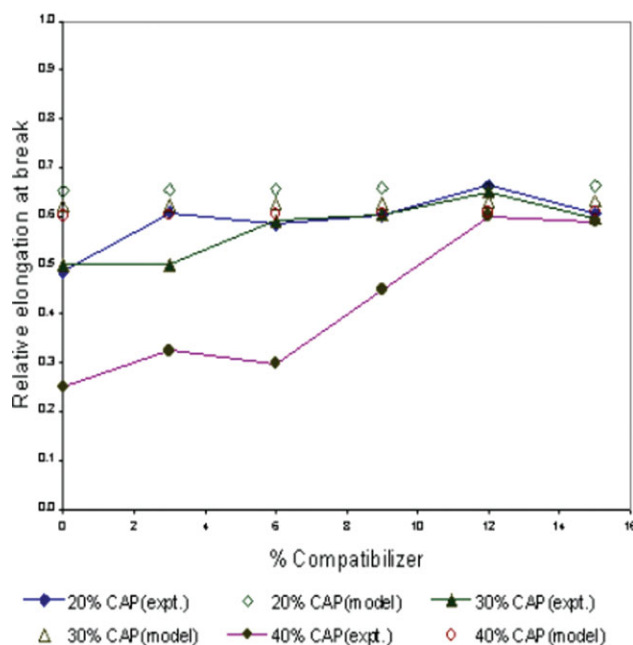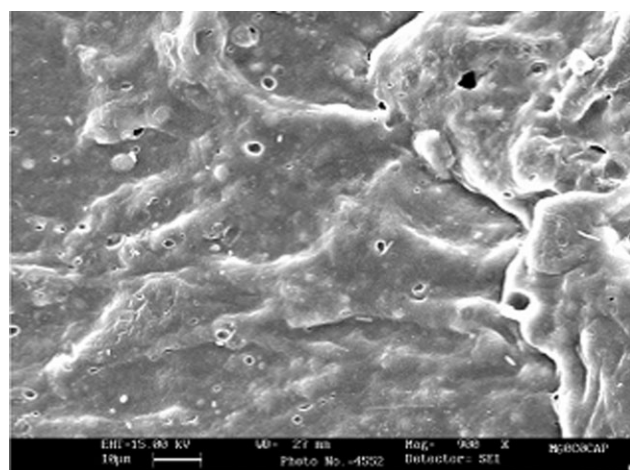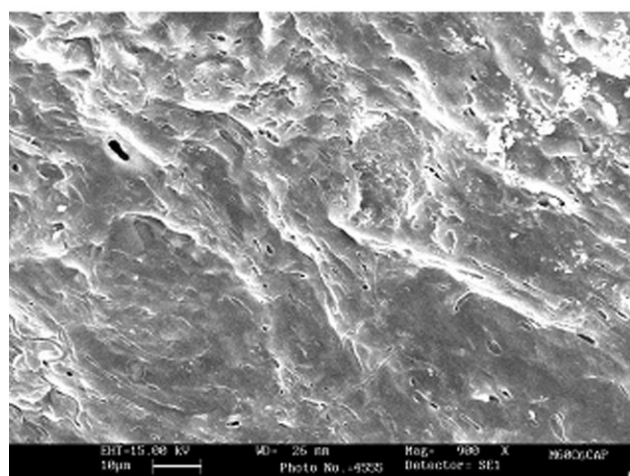

Figure 9 Plot of REB versus percentage compatibilizer for LDPE/CAP blends. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

(a)

(b)

Figure 10 SEM micrographs on blend morphology: (a) 40% CAP loading (with 0% compatibilizer) and (b) 40% CAP loading (with 6% compatibilizer).

In the above equation, ε_b and ε_o are the elongation at break for the blend and pure LDPE, respectively. k is an adjustable parameter, which depends on filler geometry. The parameter k has been varied so that the theoretical values of eq. (12) match closely with experimental values of relative elongation at break. For CAP/LDPE blends, k has been found to be 0.45. The values predicted by Nielsen's model are also shown in Figure 9. The experimental values are lower than the theoretical values although the REB values for compatibilzed blends are a little closer.

Blend morphology

Figure 10 shows the blend morphology for 40% CAP loaded blends. The blends were put in sulfuric acid for 1 h to remove CAP particles. Figure 10(a) shows morphology of uncompatibilized blend with 40%
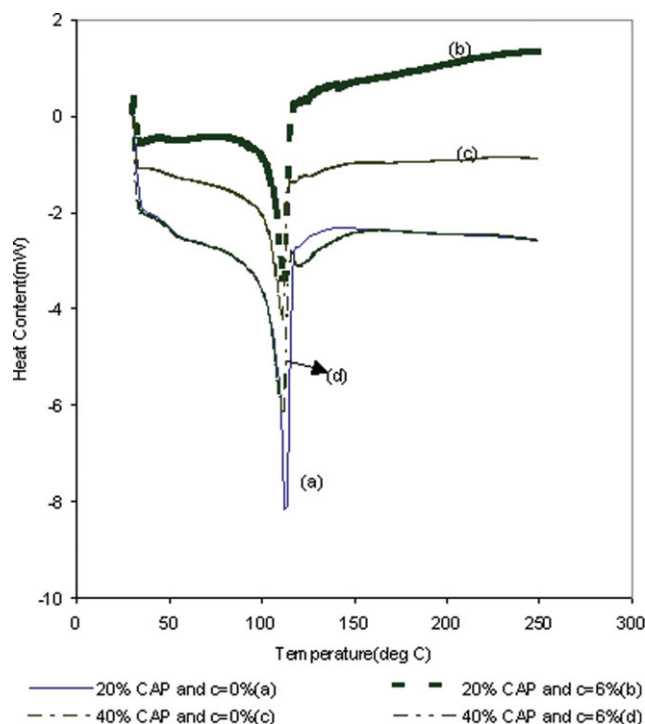

Figure 11 DSC thermograms for LDPE/CAP blends: Curve (a) is for 20% CAP loading (0% compatibilizer), Curve (b) is for 20% CAP loading (6% compatibilizer), Curve (c) is for 40% CAP loading (0% compatibilizer), and Curve (d) is for 40% CAP loading (6% compatibilizer). [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

CAP loading. The holes left by CAP particles are circular in nature, which suggests that the particles could be removed easily from the loosely bound matrix, although some resistance by the matrix is observed. The compatibilized counterpart [Fig. 10(b)] shows much smaller but protruded voids interlocked with the matrix indicating good dispersion and adhesion of the filler with the matrix.

Differential scanning calorimetry (DSC)

The DSC plots for uncompatibilized and compatibilized CAP/LDPE blends are shown in Figure 11. There is not much variation in the peak temperatures for all the blends. ΔH_f for the blends can be obtained by determining the area under the curves.

TABLE III
DSC Thermogram Values for LDPE/CAP Blends

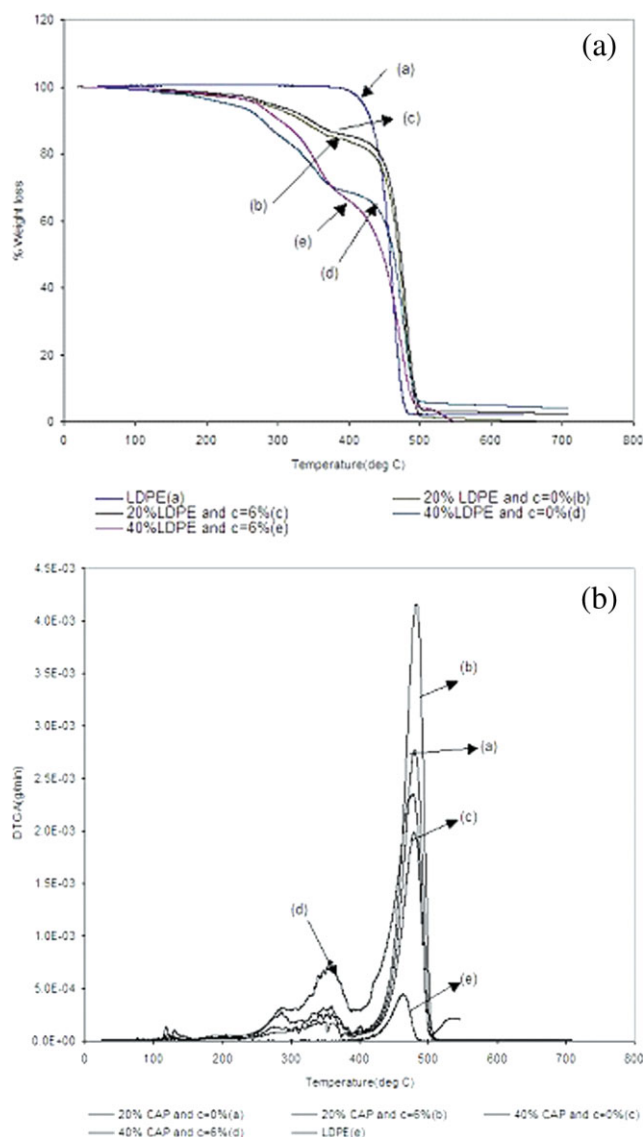|	Peak temperature (°C)	% Crystallinity (X_c)
LDPE	117.0	33.7
20% CAP ($C = 0\%$)	113.03	18.369
20% CAP ($C = 6\%$)	112.37	16.288
40% CAP ($C = 0\%$)	111.51	11.558
40% CAP ($C = 6\%$)	111.44	15.256

Figure 12 TGA/DTG curves for LDPE/CAP blends: (a) TGA curves for the blends and (b) DTG curves for the blends. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Hence, the percentage crystallinity (X_c) was calculated as follows.

$$\% \text{ crystallinity } (X_c) = \frac{\Delta H_f}{\Delta H_f^o} \times 100 \qquad (13)$$

In eq. (13), ΔH_f is the heat of fusion for 100% crystalline LDPE and this is taken to be 287.6 J/g.[15] Table III shows the peak temperatures and percentage crystallinity (X_c) for the blends. The percentage crystallinity reduces by the addition of CAP to the blend by 45%. Addition of CAP to LDPE restricts the close packing of chains segments. Addition of compatibilizer further changes the percentage crystallinity, which suggests that there are strong inter-

actions between the blend components. However, there was a slight increase in crystallinity on adding compatibilizer for higher, that is, 40% CAP loading. Similar observations have been made in the case of certain polyolefin blends.[16–18] It was suggested that this resulted due to increased crystallinity due to positive deviation from the additivity rule.

Thermogravimetric analysis (TGA)

Figure 12(a,b) shows the TGA and DTG thermograms for CAP/LDPE blends. The TGA/DTG thermograms for pure LDPE are also given in the figure. Neat LDPE (curve (a)) undergoes single stage degradation at 465°C with 71% weight loss due to the breakage of —C—C— backbone. All the blends (both compatibilized and uncompatibilized) undergo two-stage degradation at 350°C and 480°C. The first peak at 360°C is due to the breakage of glucosidic units in CAP while the second peak is for LDPE degradation. For 20 and 40% CAP loading only a portion of CAP (14 and 25% respectively) degradation at 360°C. The rest of the CAP may be encapsulated by the LDPE matrix thermogravimetric analysis helps in monitoring quality control of blends.

CONCLUSIONS

In this study, CAP has been blended with LDPE using LDPE-grafted maleic anhydride as compatibilizer. The impact and tensile strength values improved considerably for compatibilized blends almost at par with neat LDPE. SEM micrographs for 20% CAP loading showed ductile fracture while for 40% CAP loading, quasi-brittle fracture was observed. TGA studies showed two-stage degradation for these blends. Differential scanning calorimetric studies showed a lowering of crystallinity for the LDPE phase due to compatibilization as close packing of chains is inhibited. The ester and hydroxyl groups of CAP react with the carboxylic group of compatibilizer leading to good dispersion of CAP in LDPE matrix, which results in improved stress transfer from matrix to filler.

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