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Morphological, mechanical and thermal properties of nylon 6/ABS blends using glycidyl methacrylate-methyl methacrylate copolymers

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Nylon6 is an attractive polymer for engineering applications because it has reactive functionality through amine and carboxyl end groups that are capable of reacting. For this reason, it has been used a lot in polymeric blends. Blends of nylon6/ABS (acrylonitrile-butadiene-styrene) were produced using glycidyl methacrylate-methyl methacrylate (GMA-MMA) copolymers as compatibilizer. The binary blends were immiscible and exhibited poor mechanical properties that stemmed from the unfavorable interactions among their molecular segments. This produced an unstable coarse phase morphology and weak interfaces between the phases in the solid state. The presence of the copolymer in the blends clearly led to a more efficient dispersion of the ABS phase and consequently optimized Izod impact properties. However, the compatibilized blend showed poor toughness at room temperature and failed in a brittle manner at subambient temperatures.

1. Introduction

New polymers can be obtained by copolymerization or polymer blending. Polymer blends are more economically attractive than the copolymerization process and offer a diversity of possible routes for obtaining materials with desirable properties. The use of polymer blending to improve the impact strength of semicrystalline thermoplastics is specially interesting and is known as toughening process. The toughening process increases a material's capacity to absorb and dissipate plastic energy before fracture [1]. Nylon 6 (Ny6) is an important engineering thermoplastic that generally requires the addition of impact modifiers to enhance its performance under impact. Blends of Ny6 and different types of polymers have been produced to improve its toughness [1–3]. Generally, the binary blends are immiscible and exhibit poor mechanical properties that stem from the unfavorable interactions between their molecular segments. Thus, there is great interest in developing compatible blends in order to retain the desirable properties from each of the blend constituents. For this reason, one of the preferred routes has been to use reactive compatibilization in which a copolymer is premade or formed *in situ* during melt processing through the use of appropriate reactive functionalities. In this case, a compatibilizer capable of reacting with a blend constituent and that is miscible with another is added into the blend, i.e., it is necessary that it stays preferentially at the polymer-polymer interfaces [1, 4, 5–7]. Nylons are attractive for this application because they have reactive functionality through amine and carboxyl end groups capable of reacting to form graft moieties [2, 8–15].

The focus of this study was obtain a series of poly(methyl methacrylate-co-glycidyl methacrylate) (MMA-GMA) copolymers as compatibilizers of Ny6/ABS blends to control the morphological, mechanical and thermal properties of these blends. This copolymer has PMMA segments that appear to be miscible with the styrene-acrylonitrile (SAN) phase of acrylonitrile-butadiene-styrene (ABS) and the epoxide groups can react with amine and carboxyl end groups of the Ny6 to form graft copolymers at the interface between Ny6 and ABS rich phases. The morphology and impact strength of the blends were evaluated as a function of blend composition and the presence of compatibilizer.

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TABLE I Materials used in this study

Material	Description	Composition	Molecular weight (g/mol)	Haake[d] Torque (N.m)	Source
Nylon 6	Ultramid B3	End-group content: NH_2.43.2 μeq g^{-1}; COOH. 51.5 μeqg^{-1}	$M_n = 21000$[a]	1.07	Basf
ABS	SAN-grafted emulsion rubber	50% rubber 25% AN in SAN	$M_n = 40000$[b] $M_W = 110000$[b]	10.4	Nitriflex SA (Bayer)
MMA-GMA	Poly(methyl methacrylate-co-glycidyl methacrylate)	10 wt% GMA	$M_n = 21600$[c] $M_W = 91300$[c]	0.1	Synthesized in laboratory

[a] Measurements were taken by end group chemical analysis.

[b] Molecular weight of the SAN matrix grafted free. determined by GPC.

[c] Determined by GPC.

[d] Torque was taken at 240°C and 60 rev min-1 after 10 min.

2. Experimental

Table I summarizes the characteristics of the materials used in this study. The nylon 6 is a commercially available material with $M_n = 21000$ g/mol and 43.2 μeq g^{-1} of amine and 51.5 μeq g^{-1} of carboxyl end-groups. Prior to each processing step, all nylon-containing materials were vacuum dried in an oven for at least 24 h at 80°C to remove absorbed water. An emulsion-prepared ABS material was used as impact modifier, which contains 50 wt% rubber in the form of polydisperse particles typically in the range 0.18–0.20 μm diameter and a SAN matrix containing 25 wt% AN. Methyl methacrylate (MMA) and glycidyl methacrylate (GMA) monomers were supplied by Merck and Metacril. The MMA-GMA copolymer was synthesized with 10 wt% GMA by bulk polymerization. The appropriate amounts of each monomer and 2 wt% of ethyl acrylate (added to prevent unzipping of the polymer at melt processing temperatures) were premixed in a flask, 2.2′-azobis(2-methylpropanonitrile (AIBN) was used as initiator (Alfa Aesar, A Johnson Matthey Company). The procedures for synthesizing these copolymers are described in detail elsewhere [1].

The Ny6/ABS blends were prepared in a corotating twin-screw extruder (B&P Process Equipment and Systems) at 230°C and 170 rpm. The blends were quenched subsequently in water, pelletized, and dried in a vacuum oven for 24 h at 80°C. Samples for tensile and Izod impact tests were prepared by injection molding in a Arburg Allrounder machine at 230°C and mold temperature set at 50°C. Tensile properties were measured using a universal tensile machine (Instron model 5569) with a crosshead velocity of 50 mm/min according to ASTM D638. Izod impact tests were carried out on notched specimens at room, low and high temperatures using a CEAST, Resil 25, equipment with a thermal chamber, according to ASTM D256. Typically, five or more sets of samples of a given blend were placed in the chamber at once allowing the specimens to be conditioned at the desired temperature for up to 1 h, before testing. The ductile-to-brittle transition temperature was defined as the mid-point in the step-like change in plots of Izod impact strength versus temperature. Rheological measurements were made in a Haake torque rheometer with a 50×10^{-6} m^3 mixing head and standard rotors, operated at 240°C and 60 rev min^{-1}.

The phase morphologies of the blends were observed by transmission electron microscope (TEM), Philips CM 120, operating at an accelerating voltage of 120 kV. Samples were cryogenically microtomed into ultrathin sections (~20 nm thick) from Izod bars perpendicular to the flow direction with a diamond knife using a Riechert-Jung Ultracut E under cryogenic conditions (−50°C) inside the microtoming chamber. A cutting speed of 0.1 mm s^{-1} was maintained throughout the microtoming operation. The ultrathin sections were then collected on copper grids for subsequent staining operations. Various selective staining techniques were used to induce electron density changes required for mass contrast of the phases in the transmission electron microscope. The sections were exposed to 2 wt% aqueous solution of phosphotungstic acid (PTA) to stain the nylon phase. In certain cases, osmium tetroxide vapour (OsO_4) was used to stain the unsaturated rubber phase in ABS.

Differential scanning calorimetry (DSC) was used to characterize the melting and the crystallization behavior of Ny6/MMA-GMA blends. Samples taken from moulded specimens were tested through a Modulated DSC from TA Instruments, model 2920. The samples were first heated room temperature up to 260°C and kept for 3 min before cooling down to room temperature. A second heating was used to observe the melting behavior of the Ny6/MMA-GMA blends. All heating and cooling steps were done at 10°C/min. At least two DSC tests were done for each sample.

Samples for the dynamic mechanical thermal analysis (DMTA) were prepared by Arburg Allrounder injection moulding process at 230°C, with a mould temperature of 50°C. The dynamic mechanical thermal analysis was conducted using a Polymer Laboratories, model Mk II, at 3°C/min and a frequency of 1 Hz.

3. Results and discussion

3.1. Rheological properties

Fig. 1 shows the variation in torque after 10 min of mixing at 240°C of Ny6/MMA-GMA with 10 wt/% GMA content in the copolymer. A Haake torque rheometer

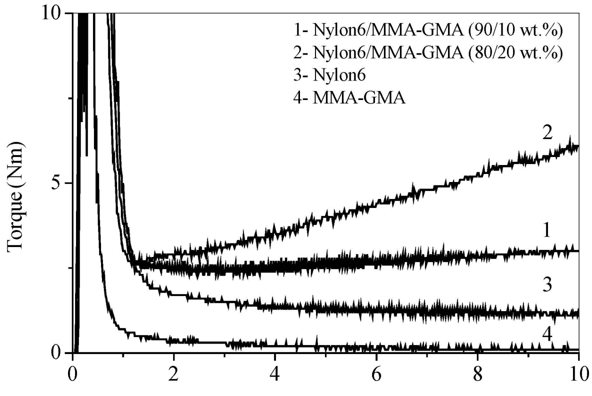

Figure 1 Haake torque rheometer of Ny6/MMA-GMA mixtures versus time (fluxing temperature was 240°C).

was used to assess the degree of grafting that occurs in these systems during melt blending. There is an increase in torque with the Ny6 and GMA mixture, which is evidence of a viscosity increase. This increase is consistent with the formation of graft copolymers during melt mixing. However, as shown in Fig. 2, an increase in torque was also observed with the ABS and MMA-GMA mixture. It is possible that metal ions and other contaminants from the polymerization and recovery processes of emulsion-made ABS materials have an influence on the reactions with epoxides [16]. On the other hand, various cross-linking-type effects may occur with difunctional molecules as Ny6.

To evaluate the T_g behavior, blends of PMMA/SAN (50/50 wt%) were prepared by solution casting from chloroform and their the behavior was observed by differential scanning calorimetry (DSC) measurements using the glass transition temperature criterion [1]. Fig. 3 shows the T_g behavior of PMMA/SAN blends. DSC technique was used in this work to show the tendency for the T_g behavior of the blends. As expected for miscible blends [17], the films of PMMA/SAN blends were transparent and exhibited a single T_g, with intermediate values between both individual PMMA and SAN T_g's.

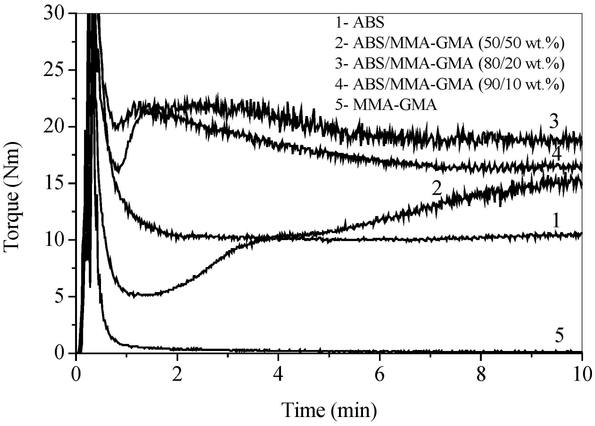

Figure 2 Haake torque rheometer of ABS/MMA-GMA mixtures versus time (fluxing temperature was 240°C).

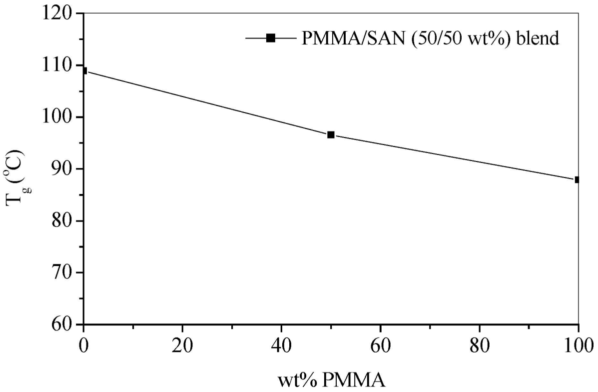

Figure 3 Glass transition temperature behavior of PMMA/SAN (50/50 wt.%) blends determined by DSC at 10°C min^{-1}.

3.2. Mechanical properties

Table II shows the results obtained for the tensile and Izod impact strength of the 70/30 and 50/50 blends. The presence of ABS (30 wt%) in the blend decreased the yield strength, tensile modulus and elongation at break as compared with pure Ny6. This reduction is yet more accentuated with the introduction of 50% ABS. This behavior was expected partially because the yield strength and tensile modulus values of ABS are inferior of the Ny6. However, the significant reduction of the elongation at break of the blend reveals the incompatibility of this system. Despite the fact that ABS displays a high impact strength because of the presence of a rubber phase in its microstructure, the impact strength of the binary blends was not increased sufficiently by simply adding ABS to Ny6. The impact strengths for the blends were low (Table II) and the fracture surfaces appeared brittle to the naked eye. Incorporation of the MMA-GMA copolymer produces a significant increase in the impact strength of the blends compared to the uncompatibilized one. Kim *et al.* [18] reported that the sequence of the mixture and the large viscosity difference between the two components alters the morphological, rheological, and dynamic mechanical properties of the blend. For this reason, blends were prepared in different sequences of mixture to improve these properties. However, Ny6/ABS/MMA-GMA systems do not seem to be sensitive to the mixture sequence, i.e., no improvement was observed in the properties with changes in the mixture sequence. Even so, the compatibilized blend can be considered as tough at room temperature if compared to other toughened plastics such as high impact polystyrene (HIPS), which has an Izod impact strength of ~100 J/m. Although significant improvements in the impact strength were observed for Ny6/ABS/MMA-GMA blends, no supertough composition was found as observed by Kudva *et al.* [4].

3.3. Influence of temperature on impact properties

Figs 4 and 5 show the behavior of the notched Izod impact strength as a function of the testing temperature. The binary blend is essentially brittle over the

TABLE II Mechanical properties of Ny6/ABS/MMA-GMA blends

Samples	Yield strength (MPa)	Tensile modulus (GPa)	Elongation at break (%)	Izod impact strength (J/m)
Ny6	72.4 ± 1.2	2.9 ± 0.04	87.2 ± 8.0	31.9 ± 3.5
ABS	14.6 ± 0.2	1.0 ± 0.00	181.6 ± 8.7	396.3 ± 7.9
Ny6/ABS (70/30%)	36.6 ± 1.0[a]	1.8 ± 0.04	65.7 ± 6.3	69.8 ± 3.0
Ny6/ABS/MMA-GMA (66.5/28.5/5 wt%)	45.1 ± 0.2	2.1 ± 0.03	50.3 ± 17.7	191.0 ± 13.7
Sequence 1	32.3 ± 0.7	1.1 ± 0.04	137.9 ± 5.8	123.0 ± 12.4
Sequence 2	30.3 ± 2.7	1.1 ± 0.07	245.1 ± 4.1	135.2 ± 14.0
Sequence 3	32.4 ± 0.2	1.1 ± 0.03	260.2 ± 3.5	108.9 ± 0.9
Sequence 4	25.9 ± 0.5	1.0 ± 0.02	271.1 ± 3.9	98.9 ± 6.4
Ny6/ABS (50/50%)	26.7 ± 0.5	1.4 ± 0.05	64.9 ± 6.4	82.2 ± 2.4
Sequence 5	34.6 ± 0.7	1.6 ± 0.06	246.7 ± 11.6	229.0 ± 22.4
Sequence 6	35.8 ± 0.2	1.7 ± 0.04	190.0 ± 8.9	144.5 ± 11.0

[a] Taken at 30% of inclination. For the other blends values taken at zero inclination.

Measurements were taken at 23 ±2°C and de 65 wt% humidity.

- Sequence 1 = Ny6/MMA-GMA + ABS (66.5/5 + 28.5 wt%).
- Sequence 2 = ABS/MMA-GMA + Ny6 (28.6/5 + 66.5 wt%).
- Sequence 3 = Ny6/ABS + MMA-GMA (66.5/28.5 + 5 wt%).
- Sequence 4 = Ny6/MMA-GMA + ABS/MMA-GMA (66.5/2.5 + 28.5/2.5 wt%).
- Sequence 5 = Ny6/ABS/MMA-GMA (47.5/47.5/5 wt%).
- Sequence 6 = ABS/MMA-GMA + Ny6 (47.5/5 + 47.5 wt%).
- Tangent modulus at 0.5%.

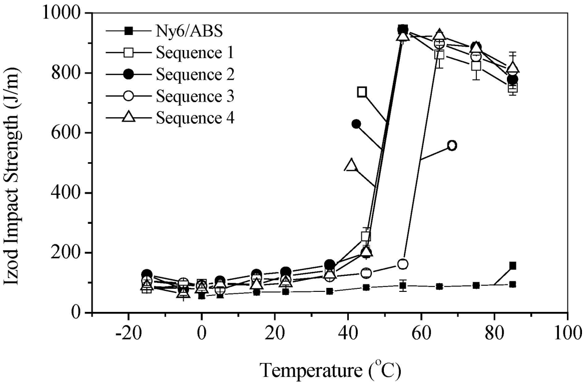

Figure 4 Effect of temperature on the Izod impact strength for a binary Ny6/ABS (70/30) blend and ternary Ny6/ABS/MMA-GMA (66.5/28.5/5) blends with different mixture sequence. Sequence 1—Ny6/MMA-GMA + ABS; Sequence 2—ABS/MMA-GMA + Ny6; Sequence 3—MMA-GMA + Ny6/ABS; Sequence 4—Ny6/MMA-GMA + ABS/MMA-GMA.

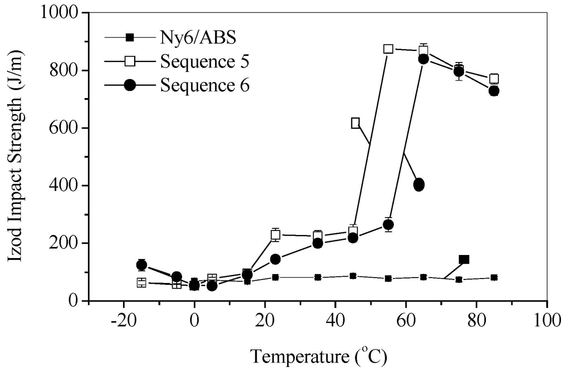

Figure 5 Effect of temperature on the Izod impact strength of a binary Ny6/ABS (50/50) blend and ternary Ny6/ABS/MMA-GMA (47.5/47.5/5) blends with different mixture sequences. Sequence 5—Ny6/ABS/MMA-GMA; Sequence 6—ABS/MMA-GMA + Ny6.

entire range of test temperatures. When the MMA-GMA compatibilizer is incorporated into the blend, a modest improvement in the impact strength of the blend at room temperature is observed compared to the binary Ny6/ABS blend. The ductile-brittle transition temperature (T_{D-F}) for the whole sequence remains in the range of 50–55°C, which is close to the glass transition temperature (T_g) of Ny6. Incorporation of ABS and the MMA-GMA compatibilizer and sequence of the mixture did not improve the impact strength of the blend significantly at room temperature or below. Only above T_{D-F} did the blend show supertough behavior. It is evident that this copolymer promotes a compatibilizing effect in the Ny6/ABS blend at room temperature, but it cannot be compared to the values obtained by [4]. However, the blend can be considered as tough at room temperature.

3.4. Thermal properties

Table III shows melting and crystallization characteristics for Ny6/MMA-GMA blends obtained from injection-moulded parts, after melt blending. The first heating run shows that the melting temperature (T_{m1}) for the Ny6/MMA-GMA blends is lower than for plain Ny6. However, the decrease in T_{m1} values for the blends are not so significant. That trend is similar for any change in the blend composition. Depression in T_{m1} could be a result of miscibility between Ny6 and grafted PA6-g-MMA-GMA molecules. For MMA-GMA copolymer in the Ny6 it can be observed that T_c and X_c (degree of crystallinity) decrease but this decrease is not so significant. This can indicate that crystallization of PA6 was inhibited of the presence of copolymer and this can be attributed the presence of many small crystallites and not perfect according to Huang *et al.* [19]. Probably, this copolymer changes the characteristics of the molecules of Ny6 under crystallization. On the other hand, no significant difference was observed either in the melt temperature a in the fusion heat (ΔH_{F2}) in the second heating of the mixtures as compared with the Ny6. In spite of the fact that MMA-GMA copolymer alters the fusion, the involved energies do not change significantly. For this reason,

TABLE III Melting and crystallization parameters for Ny6/MMA-GMA blends

	First heating		Cooling		Second heating		
Samples (Weight%)	T_{m1} (°C)	ΔH_{m1} (J/g)	T_c (°C)	ΔH_c (J/g)	T_{m2} (°C)	ΔH_{m2} (J/g)	D.C. X_c (%)
Ny6							
100	223.5	56.6	191.1	69.1	222.0	48.4	25.3
Ny6/MMA-GMA (10%GMA)							
95/5	223.5	56.9	189.8	63.8	221.3	47.2	24.7
90/10	222.3	57.1	188.5	64.3	220.0	47.3	24.7
80/20	222.7	50.4	186.5	56.3	219.7	44.7	23.4

T_m: Melting temperature taken at the melt peak;
T_c: Crystallization temperature taken at the crystallization peak;
ΔH_m: Heat of fusion due to Ny6 melting, measured through the melting peak;
ΔH_c: Heat of crystallization due to Ny6 crystallization, measured through the crystallization peak;
X_c: Degree of crystallinity, taken from $\Delta H_{m2}/\Delta H_{mo}$;
ΔH_{m2}: Heat of fusion for Ny6 measured in the second heating;
D.C.: Degree of crystallinity;
ΔH_{mo}: Heat of fusion for PA6, 100% crystalline, 191 J/g [20].

TABLE IV Glass transition temperature and secondary transitions of Ny6/ABS/MMA-GMA blends, measured by DMTA

Samples (wt%)	ABS			Ny6	
Ny6/ABS/MMA-GMA	T_g(°C) Phase rich in PB	T_1(°C) Phase rich in PB	T_g(°C) Phase rich in SAN	T_2(°)	T_g(°C)
100/0/0	–	–	–	−54.7	57.9
0/100/0	−65.9	−40.6	112.0	–	–
70/30/0	−69.5	−46.6	110.5	102.1	55.9
Sequence 1	−70.2	−47.2	102.8	–	41.2
Sequence 2	−70.9	−48.2	103.5	–	39.5
Sequence 3	−70.9	−47.5	102.0	–	37.2
Sequence 4	−70.1	−48.4	108.7	–	44.3
50/50/0	−69.2	−45.1	110.8	103.6	56.0
Sequence 5	−70.0	−45.8	112.2	107.1	45.7
Sequence 6	−69.2	−44.3	111.5	107.8	44.2

T_1: Secondary transition temperature of the rich phase in PB of the ABS.
T_2: Secondary transition temperature of the neat Ny6 and of the rich phase in SAN, to some blends.
Sequence 1—Ny6/MMA-GMA + ABS (66,5/5 + 28,5 wt%).
Sequence 2—ABS/MMA-GMA + Ny6 (28,5/5 + 66,5 wt%).
Sequence 3—Ny6/ABS + MMA-GMA (5 + 66,5/28,5 wt%).
Sequence 4—Ny6/MMA-GMA + ABS/MMA-GMA (66,5/2,5 + 28,5/2,5wt%).
Sequence 5—Ny6/ABS/MMA-GMA (47,5/47,5/5 wt%).
Sequence 6—ABS/MMA-GMA + Ny6 (47,5/5 + 47,5 wt%).

the degree of crystallinity, X_c, is not much affected by addition of the copolymer.

The dynamic mechanical thermal analysis (DMTA) was used in this work to analyze the transitions that are generally not easily detected by conventional static techniques such as DSC. Table IV shows the results obtained by DMTA for the blends and the pure components Ny6 and ABS. The tan δ peaks are the transition temperatures of the components. For Ny6 were detected two transitions in −54.7 and 57.9°C. The first transition may be the β relaxation that it is attributed to the resulting mobility of the attraction between molecular chain H and the groups C=O of the other chain. The second transition may be the T_g that it is attributed the α relaxation according to the literature [21]. For ABS, there are three transitions. The first at −65.9°C, can be attributed to T_g of the phase rich in PB. The second at −40.6°C, can be attributed to a secondary transition and the third at 112.0°C can be attributed to T_g of the phase rich in SAN. In general, it can be observed for the blends that the T_g's are close to the T_g's of the pure components and that the system is immiscible for the all studied compositions [22]. No significant change was observed in the temperatures, T_g and T_1, of the phase rich in PB for all blends studied. The differences observed can be within the experimental error. The sequences 1, 2, 3 and 4, show a significant reduction in the T_g compared to SAN. All sequences studied show a significant reduction in the T_g in relation to pure Ny6. This can be attributed to several factors such as: the epoxide ring of GMA being difunctional with respect to nylon6 that can lead to cross-linking-type effects, the epoxide group itself can also undergo a ring-opening polymerization in the presence of catalyst and the presence of emulsifier in ABS can lead to the reaction with epoxides. All these factors can have degenerated the system reducing the molecular weight and changing the T_g significantly. This can be corroborated with the DSC results through decreasing of the crystallinity degree of Ny6. It seems that the presence of MMA-GMA can modify the characteristics of the Ny6 molecules under crystallization.

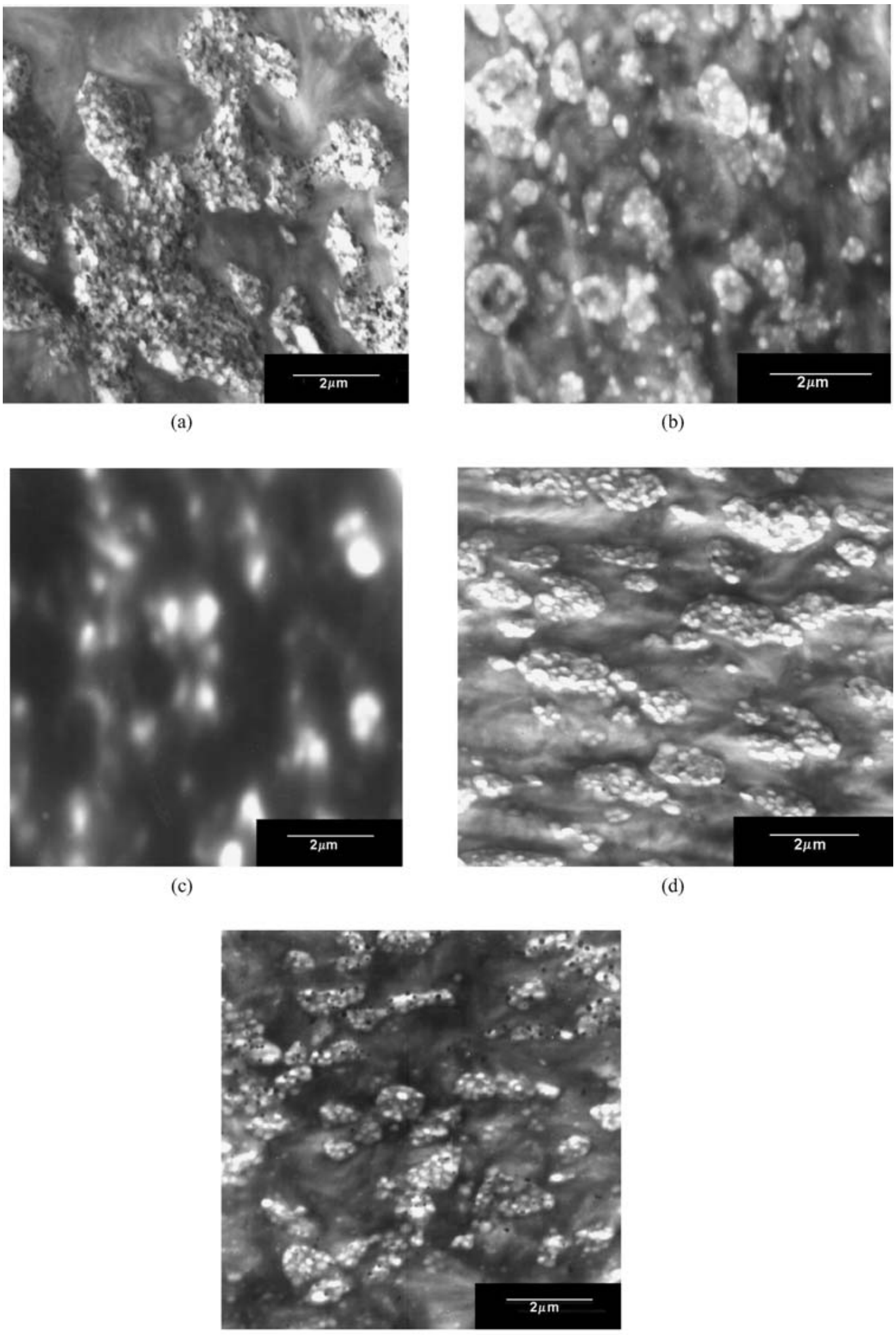

Figure 6 TEM photomicrographs of blends: (a) (70/30) Ny6/ABS blend; (b) Sequence 1—Ny6/MMA-GMA + ABS; (c) Sequence 2—ABS/MMA-GMA + Ny6; (c) Sequence 3—MMA-GMA + Ny6/ABS; (d) Sequence 4—Ny6/MMA-GMA + ABS/MMA-GMA. The nylon phase has been stained with PTA.

3.5. Morphology

Fig. 6 shows TEM photographs of binary Ny6/ABS (70/30) and ternary Ny6/ABS/MMA-GMA blends. Dark regions in Fig. 6 represent the Ny6 phase that has been stained with PTA. The photographs correlate with the compatibilizer effect on the mechanical properties described before. In Fig. 6a, nylon6 clearly forms a continuous phase while the ABS forms large domains with some tendency for interconnectivity. The poor rubber particle distribution in these blends is without doubt a major factor responsible for the poor mechanical properties observed. Moreover, these blends are brittle over the entire range of temperature studied, in agreement with the observed morphology. When the MMA-GMA copolymer is introduced in the blend, in Fig. 6b sequence 1, (c) sequence 2, (d) sequence 3 and (c) sequence 4, it seems that the co-continuity of the ABS domains is interrupted, i.e., it is as if the compatibilizer restructures the ABS domains into two populations: clusters and small domains. It seems that

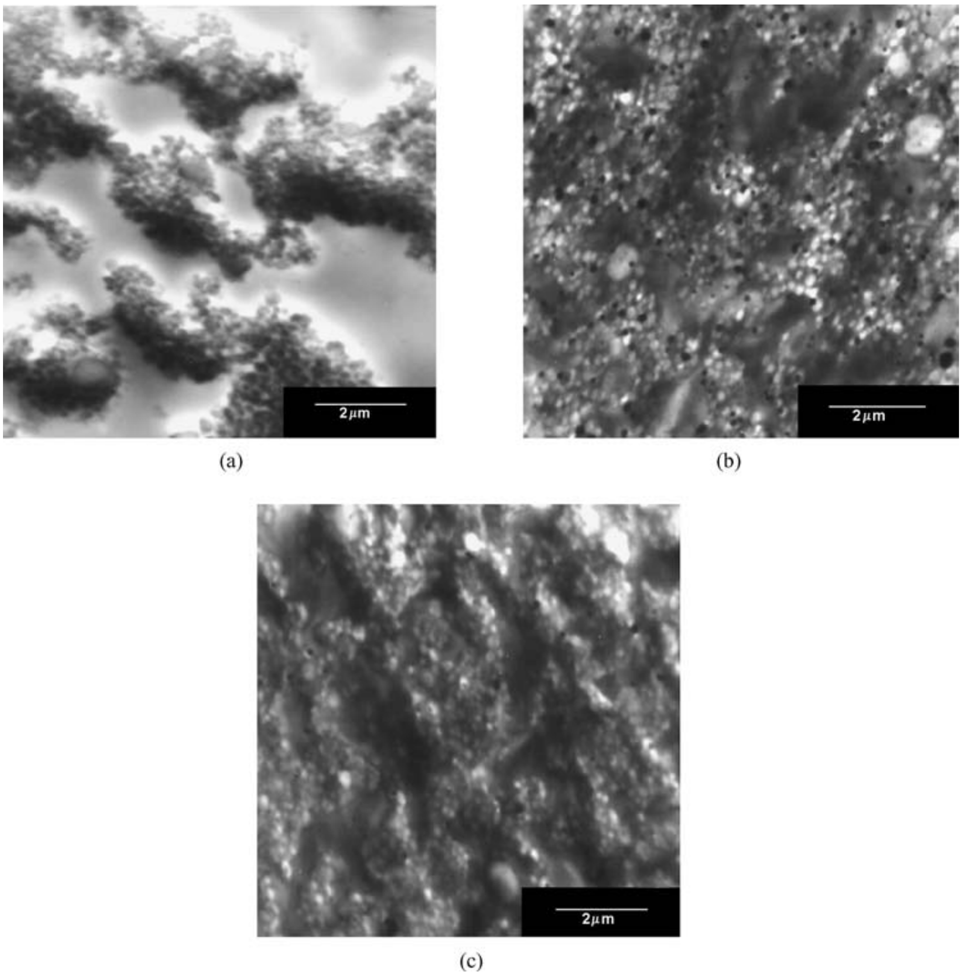

Figure 7 TEM photomicrographs of blends: (a) (50/50) Ny6/ABS blend; (b) Sequence 5—Ny6/ABS/MMA-GMA; (c) Sequence 6—ABS/MMA-GMA + Ny6. The nylon phase has been stained with PTA in (b) and (c). The unsaturated rubber phase in ABS has been stained with OsO_4 (a).

the ABS domains are more efficiently dispersed. The presence of the compatibilizer in the blends clearly demonstrates that an improved dispersion is generally accompanied by a small increase in the impact strength at room temperature of the compatibilized blends in relation to uncompatibilized blends. It can be observed too for all sequences studied that there is no significant difference in the morphology in the mixture sequence.

Fig. 7 shows the TEM photographs of binary Ny6/ABS (50/50) and ternary Ny6/ABS/MMA-GMA (47,5/47,5/5 wt%) blends. In Fig. 7a can be observed the poor rubber particle distribution in the blend similar to Fig. 6a. In Figs 7b and c (sequence 5 and sequence 6), apparently the large agglomerates of ABS in the blend become disrupted showing more dispersion but with tendency to the co-continuity. These sequences display impact strengths higher at room temperature than the former and the uncompatibilized blend. Sequence 5 possessed an impact strength value above 200 J/m. This result can be related the major content of rubber in these blends. The inability to produce well-dispersed ABS domains in Ny6 and hence to improve the toughness using MMA-GMA copolymer can be compared with the attempts to compatibilize nylon 6,6/ABS blends. The difunctionality of nylon 6,6 relative to the monofunctionality of the nylon 6 can lead to cross-linking-type effects, making it very difficult to achieve good dispersion. Both the amine and the acid end groups of the nylon 6 can react with the epoxide rings of the MMA-GMA copolymer. The nylon 6 is in this case difunctional with respect to reaction with the MMA-GMA compatibilizer. Well-dispersed rubber particles are essential for the successful toughening of nylons. It can be concluded that the MMA-GMA copolymer was not an efficient compatibilizer for the Ny6/ABS blends studied in this work.

4. Conclusions

The effect of MMA-GMA compatibilizer on a variety of properties of Ny6/ABS blends was studied. Incorporation of the MMA-GMA copolymer as a compatibilizing agent did not promote effective toughening of Ny6/ABS. Probably, the cross-linking-type reactions of this copolymer with both the acid and the amine end groups of Ny6 and ABS hindered the domain dispersion of ABS in Ny6. However, the Ny6/ABS blend compatibilized with MMA-GMA showed ductile behavior at room temperature and brittle below. The mixture sequence studied seems to influence the material properties. The DSC results showed that the incorporation of ABS and acrylic copolymers altered the crystallization process of Ny6 but the degree crystallinity of did not change significantly. DMTA technique confirmed the imiscibility of the system and determined the two T_g's of the polymer blend phases. These results are evidence that the MMA-GMA copolymer it is not very effective for the specific system.

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