

Influence of the Morphology on the Fire Behavior of a Polycarbonate/Poly(butylene terephthalate) Blend

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ABSTRACT: Polycarbonate/Poly(butylene terephthalate) (PC/PBT) blends are used in various industrial sectors, particularly in the cable industry. In this work, the fire behavior of PC/PBT blends was studied for the entire range of blend composition to investigate the relation between fire properties and blend morphology. The morphology of the binary blends used presents a phase inversion point for 25–30 wt % PBT. Various tests have been performed to characterize the fire behavior [limiting oxygen index (LOI), epradiator test, cone calorimeter, and

pyrolysis combustion flow calorimeter (PCFC)]. A change in fire behavior has been observed when the PBT content increases from 20 to 30 wt %, corresponding to the phase inversion, from a continuous rich-PC phase to a continuous rich-PBT phase. Consequently, it can be suggested that the control of the morphology of binary polymer blends is crucial to improve their fire properties. © 2012 Wiley Periodicals, Inc. *J Appl Polym Sci* 125: 3148–3158, 2012

Key words: polymer blend; morphology; fire behavior

INTRODUCTION

For many applications, fire behavior is one of the main criteria to design a material. The combustibility of plastics requires the addition of flame retardant (FR) systems. As polymer formulations become more and more complex, and particularly polymer blends, due to the presence of compatibilizing agents, additives including flame retardant, and also nanoparticles, the control of morphology of such materials is very important to maximize the performances. Hence, the dispersion of nanoparticles in a polymer or in a polymer blend has been highlighted as a key parameter for good mechanical but also good fire properties. Exfoliation or intercalation of nanoclays (organomodified layered silicates) in a polymer matrix, proved to improve strongly the performances of the material. Kashiwagi et al.¹ have quantified the dispersion of single-walled carbon nanotubes (SWCNT) in poly(methyl methacrylate) (PMMA) and characterized the materials prepared by a “coagulation” method. They showed that various properties such as storage modulus, electrical conductivity, and flammability properties were closely related to the dispersion level of SWCNT. In this study, the fire property studied is the maximum value of heat release rate (pHRR) during a cone calorimeter test.

Bourbigot et al.^{2,3} have also studied the influence of dispersion of layered silicate at the nanometric scale on the fire behavior of polymers. A decrease of 50% in pHRR at cone calorimeter tests on ethylene-vinyl acetate (EVA)-montmorillonite was obtained when dispersion of montmorillonite was achieved. But, only a reduction of 25% was noticed when the material showed only dispersion at the micronic level.² In addition, it was also shown that the type of dispersion (intercalation, exfoliation or presence of tactoids) had no effect on the fire behavior of polyamide 6-organoclay composites.³

Rafailovich et al.^{4,5} have evaluated the influence of the morphology on the fire properties of more complex formulations containing one (PMMA) or two polymers (polystyrene/PMMA), organomodified clays and flame retardant system (decabromodiphenyl ether and antimony trioxide). In both articles, they showed that the FR agents were absorbed onto the clays surface and that the exfoliation of clays could improve the dispersion of the FR agents and the fire behavior of the formulations.

Most of researches focusing on relationship between morphology and fire behavior of complex formulations have only evidenced the interest of dispersion of particles at nanometric scale. Except for the Rafailovich's work cited earlier, the influence of the detailed morphology of complex formulations on fire retardancy has never been investigated extensively. The present article aims precisely to also contribute to the understanding between the morphology of polymer alloys and their fire behavior

This first part of work concerns the fire behavior of a polycarbonate/poly(butylene terephthalate) (PC/PBT)

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polymer blend. The properties of a non miscible or partially miscible polymer blend do not follow a linear rule of mixture in the whole range of composition. Negative (and in some cases positive) deviation is generally observed. It is true for mechanical properties but also for flammability properties. Lizymol and Thomas⁶ have tested different blends: EVA/PVC [poly(vinyl chloride)], PVC/SAN (styrene-acrylonitrile), and EVA/SAN. They observed in most cases a negative deviation in comparison to a linear rule of mixtures for the blends. For example, the limiting oxygen index (LOI) of PVC/EVA blends is 38% for pure PVC and 17% for pure EVA but only 21, 18, and 17% for PVC/EVA 70/30, 50/50, and 30/70, respectively. Nevertheless, they did not correlate these observations to the morphology and in particular to the phase inversion of the blends.

In a previous work about the fire behavior of PC/poly(ethylene terephthalate) binary blends, it has been shown that some fire characteristics, such as LOI, did not depend linearly on the blend composition.⁷ In particular, a positive deviation in LOI was observed for PC-rich blends. But, no attempt was made to connect this observation to the morphology.

It is obvious that the morphology could change during the heating of the materials and during the thermal decomposition of polymers after ignition. Nevertheless, the temperature rise is very steep during a fire scenario or a fire test (some degrees per second). Moreover, in the case of a blend containing a charring polymer, a barrier effect due to the formed char is able to limit the decomposition rate of combustible materials. If, the char covers the entire sample surface, its influence on fire performance can be higher. Thus, the influence of the morphology of a polymer blend, even without any additive, could be significant.

EXPERIMENTAL PART

Vestodur (Degussa, Germany) 3000 (PBT) and Makrolon (Bayer, Germany) 2647 (PC) were purchased from Degussa and Bayer, respectively. Melt flow rate (MFR) were respectively 9 and 12.5 cm³/10 min according to ISO1133 (data from manufacturers).

Blends were dried before extrusion at 80°C under dry air conditions during one day. Then, they were extruded using a corotative Clextral BC 21 twin-screw extruder at 260°C. No additive was used to inhibit transesterification reaction occurring between PC and PBT and leading to PC-PBT copolyesters.

After drying at the same conditions as mentioned earlier, testing specimens were injection-molded using a Krauss-Maffei press 50 tons at 260°C. The mold temperature was fixed at 40°C. In the following sections, blends are called PCX, X is the weight percentage of PC [and thus (100 - X) is the weight percentage of PBT].

Dynamic thermomechanical analysis was performed using an ARES rheometer (TA Instruments) (rectangular torsion mode) according to a heating ramp from 25 to 180°C at a frequency 0.1 Hz and a deformation of 0.15%. The section of the samples is 4 × 10 mm² and their length is 25–30 mm.

Selective dissolution of PC fraction was made in boiling dichloromethane during 8 h, using a Soxhlet apparatus (cycle time was approximately 10 min). The boiling point of dichloromethane is 40°C.

Limited oxygen index was measured according to the standard ISO 4589 on 10 × 4 × 800 mm³ specimens.

Self-extinguibility was assessed using epiradiator test (NF P 92-505 standard). A 70 × 70 × 4 mm³ specimen was irradiated by an electric radiator (irradiance fixed at 30 kW/m²). Neither ventilation nor piloted flame was used. The heater was placed above the specimen up to ignition. Then, the heater was maintained for 3 s and removed. Although the specimen extinguished, the heater was placed once again above it up to ignition, and so on for 5 min. Each ignition and extinction time was recorded. Three samples were tested for each formulation.

Cone calorimeter is a powerful tool to study the fire behavior of polymers. A horizontal sample sheet of 100 × 100 × 4 mm³ was placed 2.5 cm below a conic heater and isolated by rock wool. The heating of the cone part was monitored to impose a specific irradiance at the top of the sample, in the range of 0–100 kW/m². In our work, the samples were exposed to 20 and 50 kW/m² irradiance in well-ventilated conditions (air rate 24 L/s) and in the presence of a spark igniter to force the ignition. HRR was determined according to oxygen depletion (Huggett's relation). Mass loss, CO, and CO₂ release rates and smoke opacity were also recorded continuously. The tests were performed according to the ISO 5660 standard. The precision of measurements was generally considered almost equal to 10%.

Pyrolysis combustion flow calorimeter (PCFC) is an apparatus developed firstly by Lyon and Walters⁸ for Federal Aviation Administration. PCFC enables to study the flammability of samples as small as 1–3 mg. The HRR is calculated according to oxygen depletion, as with cone calorimeter test. The great interest of this test is the separation between the pyrolysis of the solid and the combustion of the gases released during the degradation.

PCFC was used in standard conditions: the sample was heated up to 750°C at a rate of 1°C/s in pure nitrogen. The gases were evacuated to the oven and the combustion occurred at 900°C in a N₂/O₂ (80/20) atmosphere. The uncertainty is assumed to be 10% for pHRR and 1.5 kJ/g for total heat release (THR).

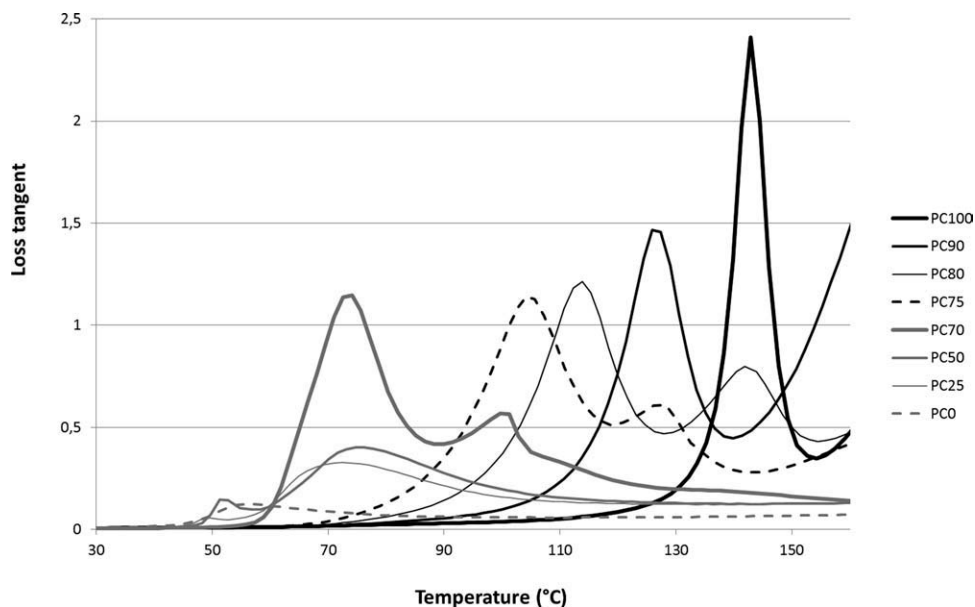


Figure 1 Loss tangent curves of PC/PBT blends.

RESULTS AND DISCUSSION

Morphology of the blends

In the literature, melt blended PC/PBT blends show different degrees of partial miscibility.^{9–11} For example, 50 : 50 PC/PBT blend exhibits lower critical solution temperature (LCST) type behavior with a spinodal temperature T_s of 198°C.¹² Thus, once a 50:50 PC/PBT blend cools below T_s during melt processing, it becomes homogeneous. However, crystallization of PBT-rich phase is still rapid and structure development within PC/PBT blends tends to be dominated by PBT crystallization which prevents significant phase dissolution. It has been shown that PBT crystallization behavior is strongly influenced by the presence of PC¹³ because PC macromolecules have been observed in the interlamellar zones of PBT.¹⁴ Moreover, the partial miscibility of the blend is partly dependent on the transesterification reaction between PC and PBT, which was described by several authors.^{11,13–16} The size scale of the morphology of the blend was found to be strongly dependent on interfacial chemical reactions. As a matter of fact, the PC-PBT copolymer formed acts to reduce the interfacial tension but also the propensity of the PBT to crystallize. Finally, during melt processing there is a competition between liquid–liquid phase separation, interfacial transesterification reactions, crystallization of PBT and reduction of the molecular weight of both PC and PBT. This complex behavior leads to different degrees of miscibility, according to various authors.^{11,14,17}

It is well known that dynamic thermomechanical analysis provide information on the miscibility of polymer blends. The study of the influence of the

miscibility of PC and PBT on the glass transition temperature was investigated by many authors^{10,18,19} using thermomechanical analysis. Loss tangent curves are given in Figure 1. Glass transition temperature is indicated by the peak of loss tangent: 143°C for pure PC and 60°C for pure PBT. Only one peak could be noticed for PC90 which indicates that for this composition, the two polymers are fully miscible. When PBT content increases, two peaks were observed, showing that the blends were made of two phases. Although the temperatures of both loss tangent peaks change drastically with the composition (Table 1), we could assume that both phases are not pure, except for PC80 blend that contains a PC/PBT continuous phase (with a majority of PC) with a pure PC dispersed phase. In this investigation, no inhibitor was used to prevent the transesterification reactions at the interface between PC and PBT, and

TABLE 1
Temperatures of Loss Tangent Peaks for PC/PBT Blends in Dynamic Thermomechanical Analysis (for Each Formulation, the Temperature of the Highest Peak is Underlined)

Formulation	Temperature of first loss tangent peak (°C)	Temperature of second loss tangent peak (°C)
PC100		<u>143</u>
PC90		<u>126</u>
PC80	112	<u>142</u>
PC75	<u>104</u>	127
PC70	<u>74</u>	100
PC50	<u>51</u>	75
PC25	50	<u>73</u>
PC0	<u>56</u>	

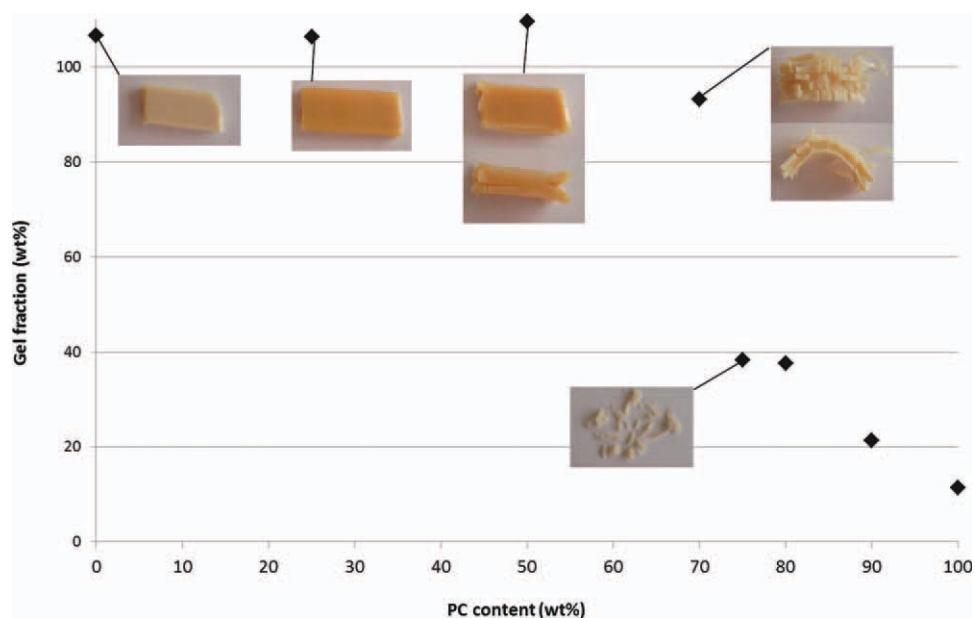


Figure 2 Gel fraction and photos of residues of PC/PBT blends after Soxhlet extraction using dichloromethane. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

therefore the partial miscibility observed is ascribed to the interchange reactions. Figure 1 shows that the peak at a lower temperature is related to a PBT-rich phase, while the peak at a higher temperature is related to a PC-rich phase. Moreover, the temperature of the main peak is higher than 96°C (this temperature corresponds to the T_g of a fully miscible PC50 calculated owing to Fox relation) for PC90–PC75, which proved that the main phase is a PC-rich phase. On the contrary, the temperature of the main peak is close to this of pure PBT for PC con-

tents in the range 25–70% (noted PC70–PC25). Thus, the major phase is a PBT-rich phase for these blends.

Then, we could assume that the phase inversion from a continuous PC-rich phase to a continuous PBT-rich phase is observed for a PBT content close to 25–30 wt %.

To verify this assumption, we tried to dissolve a small rectangular piece of our blends in dichloromethane (in a Soxhlet apparatus during 8 h; cycle time 10 min). Dichloromethane is a solvent of PC but not of PBT. For PC0–PC50, the gel fraction is

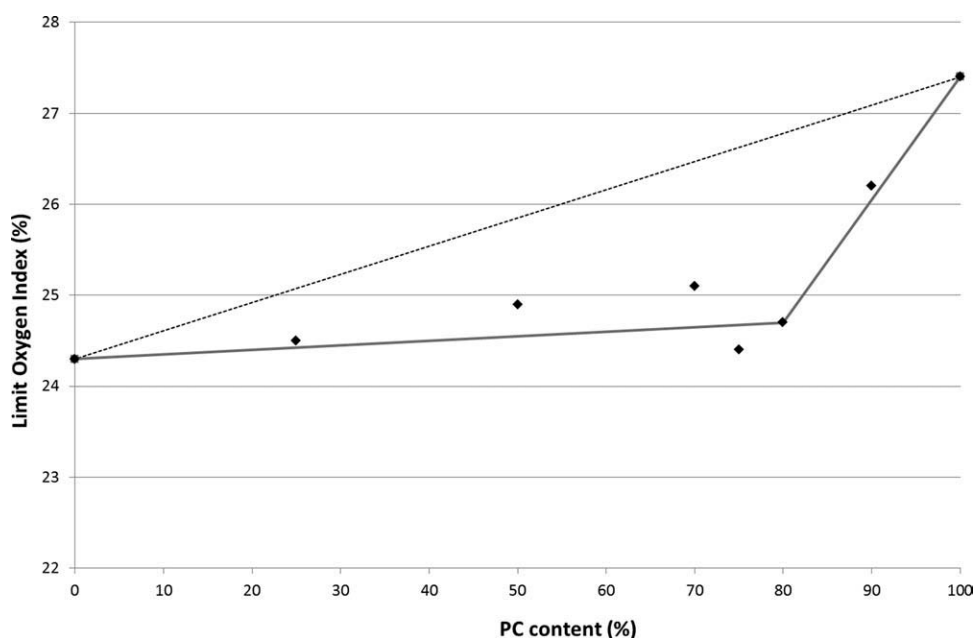


Figure 3 LOI of PC/PBT blends.

TABLE 2
Fire Behavior of PC/PBT Blends in Epiradiator Test

Formulation	Total burning time (s)	Self-extinguibility during the whole test
PC100	125	Yes
PC90	130	Yes
PC80	170	Yes
PC75	172	Yes
PC70	183	No
PC50	162	No
PC25	166	No
PC0	116 ^a	No

^a Complete burning of the sample before the end of the test.

approximately equal to 100%, indicating that the continuous phase is PBT (Fig. 2). A value slightly higher than 100% is probably due to a non complete drying of the sample and of the thimble. The gel fraction decreases for higher content of PC and particularly for PC70 and PC75, which confirms that the phase inversion point is located between these two compositions. Moreover, for PC70–PC0, the shape of the sample piece is conserved because the continuous phase is a PBT-rich phase. These results allow us to confirm the above hypothesis.

To conclude on the study of the morphology it seems very difficult to determine exactly the morphology of the PC/PBT blends (in the absence of chemical reaction inhibitors), because of the high level of miscibility. However, it can be highlighted that the phase inversion occurs between 70 and 75 wt % of PC.

Fire behavior

Obviously the fire behavior of a material is mainly controlled by its composition. Although PC has higher thermal stability and char yield than PBT, the flammability of the blends increases with increasing addition of PBT. In the following, we will focus particularly on the changes in fire properties when composition crosses through the phase inversion point (as determined previously between 70 and 75 wt %).

Limited oxygen index and epiradiator

Limited oxygen index was measured for all blends (Fig. 3). LOI increases with the content of PC which has a LOI equal to 27.4. But, this increase in LOI is not linear. From 24.3 (pure PBT), LOI increases slightly to 24.7 for PC80. Above 80 wt % of PC, LOI increases more strongly.

Self-extinguibility was also determined for all blends (Table 2). Pure PC and the blends PC90–PC75 remained self-extinguishable during the 5-min test. On the contrary, when PBT content is higher than 25 wt %, the blends are not self-extinguishable during the whole test.

According to these basic tests, a change in fire behavior occurs when the PBT content increases from 25 wt %, which corresponds to a change in morphology as seen above. Cone calorimeter and PCFC could help us to state about this correlation.

Cone calorimeter

Table 3 summarizes the main flammability properties of the PC/PBT blends in cone calorimeter tests at 50 kW/m² irradiance.

Time to ignition is minimum for PC80 and PC75, close to the phase inversion composition. Although many parameters influence the time to ignition (reflectivity, absorptivity, thermal stability, endothermic, or exothermic reactions...), it is difficult to explain this evolution. PC70–PC0 are opaque and semi-crystalline (the melting of crystallites is an endothermic reaction). On the contrary, PC100–PC75 are translucent and PBT crystallization upon cooling was inhibited during injection-molding. Moreover, possible transesterification could occur and modify thermal stability of the blends.

The effective heat of combustion (EHC) during cone calorimeter test is approximately the same for PC, PBT, and PC/PBT blends: 19–22 kJ/g. Then, the HRR is proportional to the mass loss rate (MLR) and the evolution of these values versus time is the same. A similar conclusion could be assumed between THR and total mass loss.

The evolution of HRR versus time is given in Figure 4. It could be observed that the pHRR

TABLE 3
Fire Behavior of PC/PBT Blends in Cone Calorimeter Test

	TTI (s)	pHRR (kW/m ²)	THR at 400 s (MJ/m ²)	Char yield at 400 s (wt %)	EHC (kJ/g)
PC100	70	276	71.5	26.6	21.1
PC90	58	287	74.7	25.5	20.9
PC80	49	352	76.8	21.4	20.1
PC75	50	389	77.2	21.2	18.7
PC70	65	540	84.0	18.1	20.7
PC50	62	589	84.1	14.2	21.2
PC25	73	667	90.3	8.8	20.7
PC0	71	796	99.2	5.8	18.8

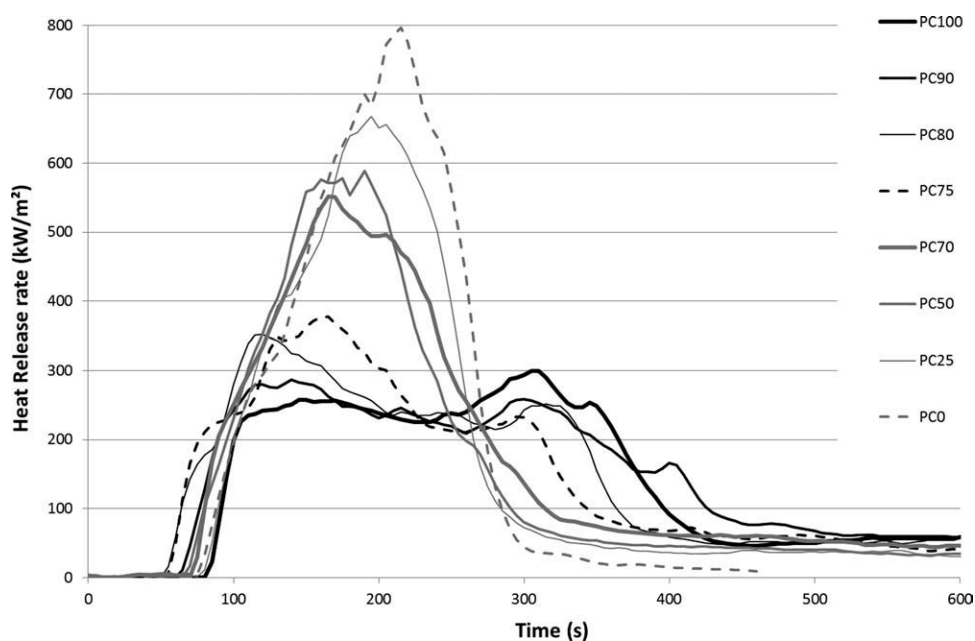


Figure 4 “HRR versus time” curves of PC/PBT blends in cone calorimeter (irradiance 50 kW/m^2).

increases continuously from PC100 (pure PC) to PC0 (pure PBT). But, a sharper increase is seen between PC75 and PC70 (Fig. 5). We could notice that an increase of 25 wt % in PBT content (from PC100 to PC75) leads to an increase in pHRR of 120 kW/m^2 (from 250 to 370 kW/m^2). But, a further addition of 5 wt % of PBT (from PC75 to PC70) leads to an increase of 180 kW/m^2 . This sharp change in the slope of the curve “pHRR versus PC content” corresponds to the change of the blend morphology as noticed previously.

A scrutiny of the curves allows this correlation to be explained. At the first few seconds after the ignition (that occurs between 50 and 75 s according to the samples), the initial slope of the curve of HRR versus time is the same for all formulations. The same observation could be drawn from the evolution of mass loss at least before 100 s [Fig. 6(a,b)]. Nevertheless, for PC100–PC75, the HRR becomes constant between 90 and 120 s at a relatively low HRR level. The decomposition continues for more than 200 s at a slow rate up to flame out. On the contrary, for

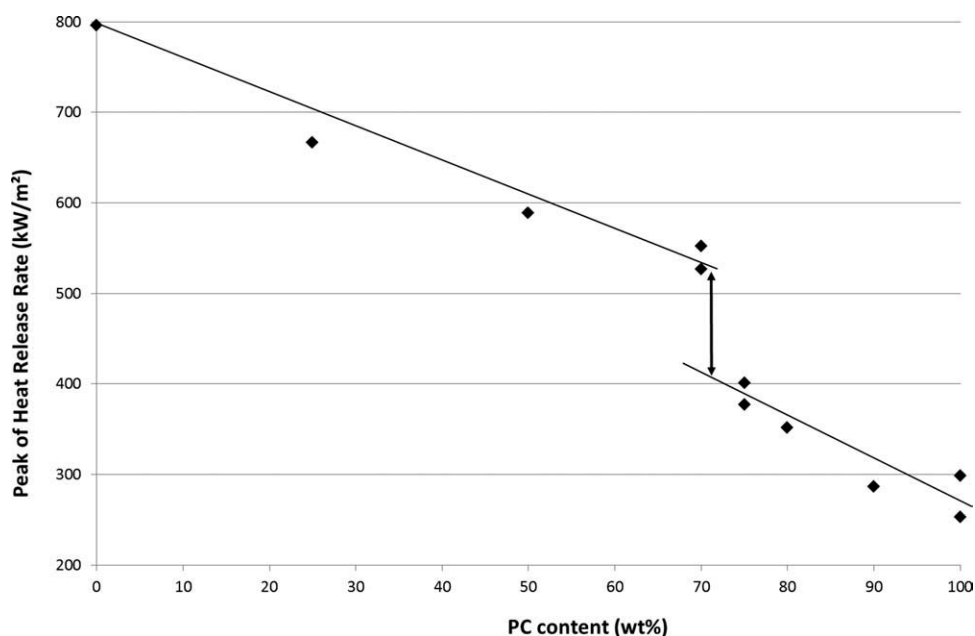


Figure 5 pHRR in cone calorimeter versus PC content for PC/PBT blends (the solid lines and the arrow show the gap in pHRR around 75 wt % of PC).

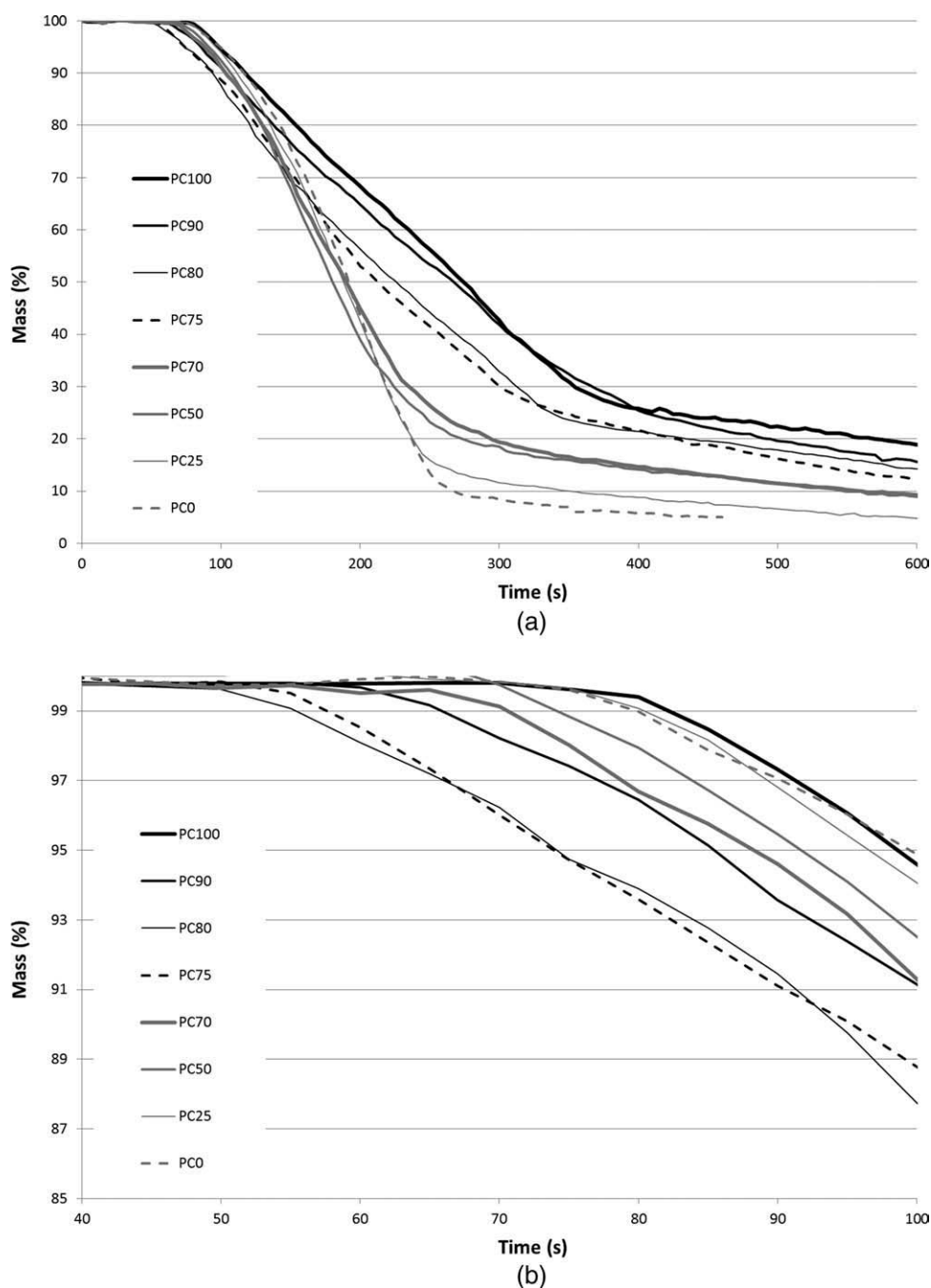


Figure 6 (a) "Mass versus time" curves of PC/PBT blends in cone calorimeter. (b) Details.

PC70–PC0, the HRR increases up to a peak value and then decreases quickly. Flame out occurs at less than 300 s after the beginning of the test. We could notice that the mass loss accelerates after 120 s approximately, while the MLR is stable for PC100–PC75 [Fig. 6(a)].

The evolution of HRR versus residual mass also highlights strong differences between PC100–PC75 and PC70–PC0 (Fig. 7). For PC100–PC75, the HRR increases up to a mass loss of 5–20%, respectively and becomes constant. On the contrary, for PC70–PC0, the HRR increases up to a higher mass loss (up

to 70% for pure PBT). Once again, a very large difference could be noticed between PC75 and PC70.

We could remark that HRR is maintained at approximately 50 kW/m^2 at the end of the test. Similarly, mass continues to decrease even after flame out, because of the oxidative degradation of char. Consequently, we decided to compare char yield and THR after a period of 400 s. For all blends, this time corresponds to the slowdown of the mass loss related to the oxidative degradation of the char. We could remark that the char yield decreases and THR increases with the increasing incorporation of PBT in

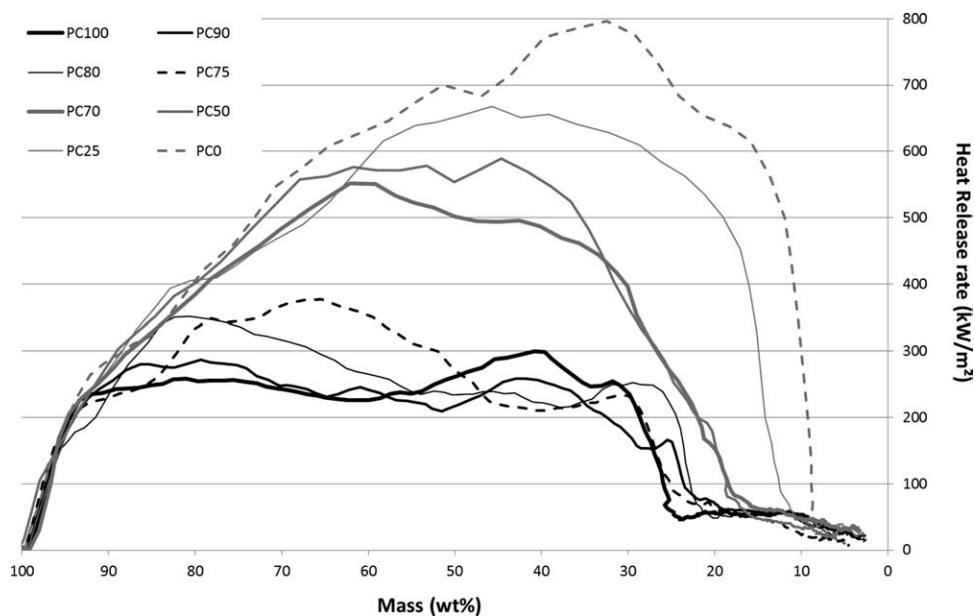


Figure 7 "HRR versus Mass" curves for PC/PBT blends in cone calorimeter.

the blend. These changes are progressive and do not present any acceleration when composition crosses through the phase inversion point.

PCFC

Results of PCFC tests are shown in Figure 8 and summarized in Table 4. The HRR of PC/PBT blends shows two peaks: the first arises between 400 and 450°C (like pure PBT) and the second between 500 and 550°C (like pure PC). Nevertheless, the area of the first peak is higher than the values calculated from the content of pure PBT. Conversely, the area

of the second peak for the blends is lower than the values calculated from the corresponding content of pure PC. Thus, we could assume that a part of PC decomposes during the first step of decomposition, maybe because the products of PBT pyrolysis would catalyze the PC degradation. Another explanation is that possible transesterification occurs during extrusion between PC and PBT leading to less stable copolymers. This is confirmed by thermogravimetric analysis (TGA). The measured char yield is slightly lower than expected yield according to the linear rule of mixtures from char yields of PC100 and PC0 (pure PC and pure PBT). Although only PC is able

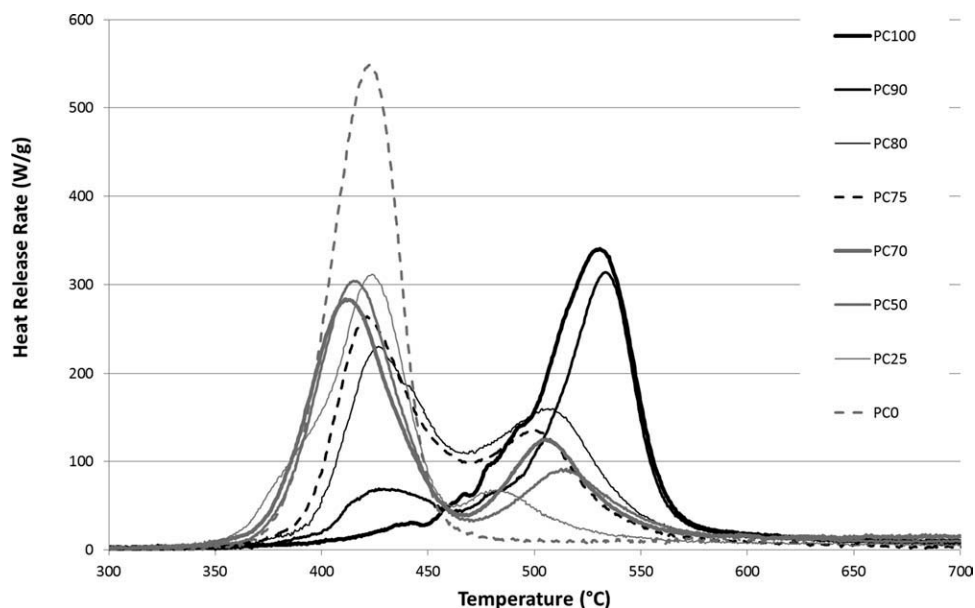


Figure 8 "HRR versus temperature" curves for PC/PBT blends in PCFC.

TABLE 4
Fire Behavior of PC/PBT Blends in PCFC Test

	pHRR (Peak 1; W/g)	pHRR (Peak 2; W/g)	THR (kJ/g)	Char yield (wt %) ^a	EHC (kJ/g) ^b
PC100	0	340	19	23.6 (23.6) ^c	24.9
PC90	69	314	18.2	20.6 (21.2)	22.9
PC80	231	160	18.6	15.7 (18.9)	22.1
PC75	241	163	19.9	13.2 (17.7)	22.9
PC70	267	101	19.0	10.1 (16.5)	21.1
PC50	304	92	19.4	6.7 (11.8)	20.8
PC25	311	68	19.1	6.3 (5.9)	20.4
PC0	550	0	20.2	0.2 (0.2)	20.2

^a From thermogravimetric analysis.

^b Calculated from THR and char yield according to the relation $EHC = THR \times 100 / (100 - \text{char yield})$.

^c Theoretical char yield according to a linear rule of mixtures is given in brackets.

to char, this result shows that a part of PC in PC/PBT blends is degraded at lower temperature and could not char.

EHC was calculated according to THR measured in PCFC and char yield measured in TGA. In this case, EHC is maximum because combustion is complete in PCFC. Thus, the calculated values are slightly higher than those measured in cone calorimeter test. Moreover EHC decreases when PBT content increases in the blend. It should be noticed that EHC in cone calorimeter is partly due to the oxidative degradation of the char while char in PCFC/TGA is more stable because these analyses are performed under nitrogen flow.

We performed PCFC tests to complete and to allow more interpretations about the results obtained with cone calorimeter tests. For decomposition with multiple peaks, Lyon and coworkers²⁰ proposed to sum the values of the different deconvoluted peaks

of HRR. In this study, the sum of the two peaks is approximately constant (except for pure PBT) and no correlation with pHRR in cone calorimeter was observed.

Despite the heating rate is not the same for PCFC and cone calorimeter (and not constant for the latter), a correlation between the peak of HRR at cone calorimeter and the first peak of HRR at PCFC (corresponding to the fraction which is degraded at lower temperature and which should degrade faster in cone calorimeter test; i.e., PBT and a part of hydrolyzed PC) could be expected. But, no correlation can be noticed (Fig. 9). We could propose a hypothesis to explain this lack of correlation. For PC100–PC75, the maximum value of the first pHRR in PCFC increases quickly while pHRR in cone calorimeter increases slowly. Then, the slope of the curve “pHRR in cone calorimeter versus first pHRR in PCFC” is low. For higher PBT content (PC70–PC0), the

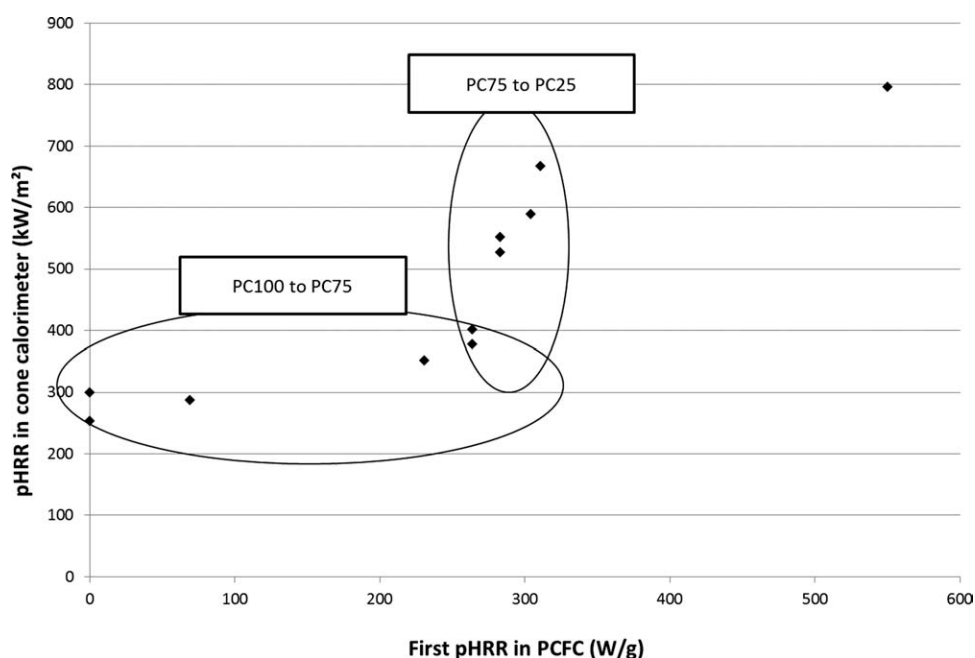


Figure 9 “pHRR in cone calorimeter versus first pHRR in PCFC” curves for PC/PBT blends.

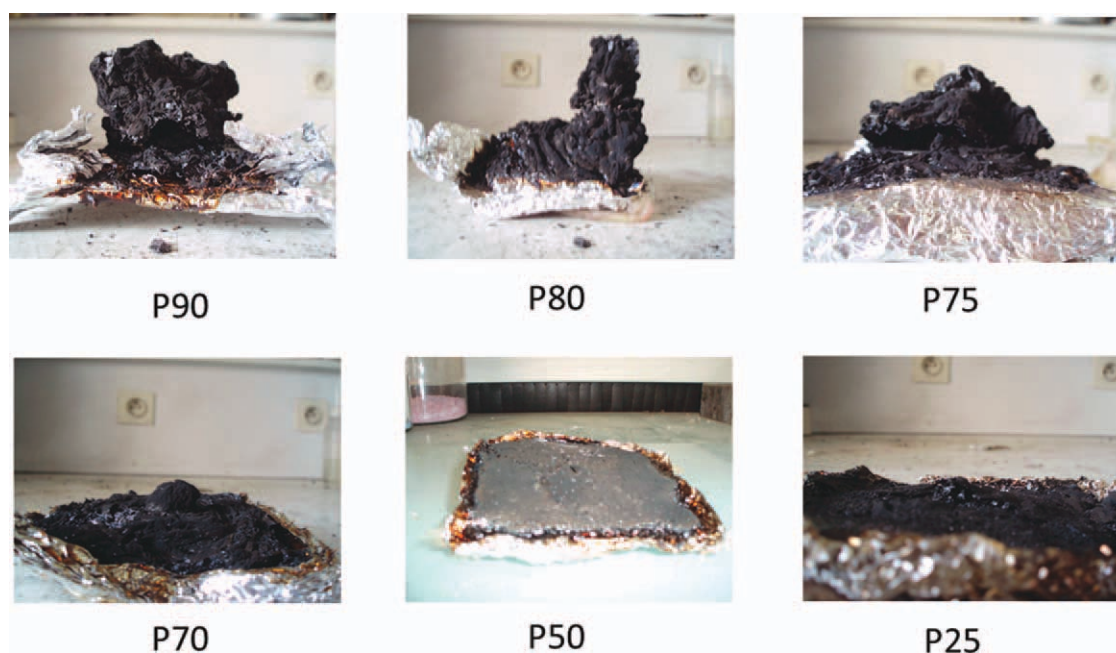


Figure 10 Photos of PC/PBT residue after cone calorimeter test at 20 kW/m^2 . [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

increase in pHRR in cone calorimeter is faster and the slope increases. Once again, this change is ascribed to the phase inversion, around 25 wt % of PBT.

The main point highlighted earlier is the strong change of the blends behavior at cone calorimeter test between PC75 and PC70, whereas only a slight difference of composition (only 5 wt % of PBT) is observed. This change in fire behavior between PC70 and PC75 was also noticed for other tests, such as LOI and epiradiator test.

We suggest that morphology evolution could explain these results. The blend consists in two phases. When the PBT content is equal or lower to 25 wt %, the main continuous phase is a PC-rich phase, which is a charring polymer. At cone calorimeter test, the char formed during the pyrolysis of PC could act as a barrier to gas and heat. This barrier is not stable and degrades during the test. But, the charring is enough cohesive to limit the decomposition rate of combustibles. On the contrary, for PC70–PC0, the continuous phase is a PBT-rich phase. PC is mainly dispersed in the matrix as nodules and no continuous charring layer could act as a barrier. Hence, the MLR increases continuously up to the lack of combustibles.

This explanation can give an account of the PCFC results and in particular of the lack of correlation between pHRR in cone calorimeter and the first peak of HRR at PCFC. When the matrix is a PC-rich phase, the barrier effect due to the PC charring limits the increase in pHRR during cone calorimeter test, even if the most flammable part of materials (PBT and a part of PC) increases. Thus, for formula-

tions PC100–PC75, the main effect governing the fire behavior can be ascribed to the chemical composition. When the matrix becomes a PBT-rich phase by increasing the PBT fraction, this barrier effect is no longer effective, PC charring could not control the HRR (and the MLR) and the pHRR in cone calorimeter increases quickly, whereas the first peak of HRR at PCFC remains almost constant. Hence, for formulations PC75–PC25, the morphology of the blend influences highly the fire behavior of the blend.

To confirm this hypothesis, we have performed cone calorimeter tests on blends at an irradiance of 20 kW/m^2 . At such low irradiance, the residue is not degraded. The photos of the residue at the end of the test are given in Figure 10. For PC100 (pure PC), no ignition occurs. It appears that for PC90–PC75, an expanded residue is formed during the test. It means that the char layer formed is able to trap gases released by the pyrolysis of solid. This result is confirmed by the shape of the curve of HRR versus time obtained by cone calorimeter tests (Fig. 4). On the contrary, for PC70–PC0, a flat residue was observed. No expansion was occurred during the test and no barrier effect due to the char formed by PC decomposition was effective.

CONCLUSION

This work presents a contribution about the relation between morphology and fire behavior of a binary blend constituted of a low flammable and charring polymer (PC) and a relatively flammable and non-

charring polymer (PBT). The relative percentage of each polymer is the main parameter which determines the fire behavior of the blend. Despite an increase in PBT content lowers the flame retardancy of the polymer blend, it appears clearly that the morphology has a significant effect on fire behavior characteristics. It has been proved that evolutions of pHRR and global shape of the cone calorimeter curve, as well as residue, LOI, and self-extinguibility depend on the morphology. A noticeable change in these characteristics was observed at the inversion phase point (near 25 wt % in PBT content).

This statement suggests that improvements of fire properties of a complex formulation are possible through the control of polymer blends morphology.

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