Chemical Resistance Of Polystyrene/ Polypropylene Blends: Effect Of Blend Compositions And SEBS Content

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ABSTRACT: *Polystyrene (PS) is widely used in packaging, building and construction, and injection molding application due to advantages of being clear, hard, easily processed and low cost. However PS lack in toughness and chemical resistance toward certain chemicals such as ketones. Blends of PS with Polypropylene (PP) are developed with the objective to enhance the impact and chemical resistance of PS. However, the blends of PS and PP are known to be immiscible and incompatible. Previous studies have concluded that the block copolymer such as styrene-b-(ethylene-co-butylenes)-b-styrene (SEBS) is good compatibilizer for this PS/PP blends. The present study investigates the effect of SEBS on the chemical resistance on the PS/PP blends. Using a Brabender PL2000 twin-screw extruder, blends of PS/PP in various composition ranging of 90–60 wt % PS containing different amount of SEBS in the composition range of 5-25 phr were prepared and injection molded to evaluated for chemical resistance. The chemical resistance testing was carried out according to ASTM D543-87. The specimens were placed in appropriate containers for the reagents being used, and allow the specimens to be totally immersed in fresh reagent for 7 days in the Standard Laboratory Atmosphere. The results show the chemical resistance of PS to acetone (ketone) increases with increasing PP content. On the other hand, the chemical resistance of PS/PP blends increases with increasing SEBS content at lower PP content. However, at higher PP content, the chemical resistance decreases with increasing SEBS content.*

INTRODUCTION

Blending of polymers provides an efficient way of developing new materials with tailored properties and thus has received much attention from academia and industry [Paul and Newton, 1978]. The continuing pressure to reduce the costs, improve productivity, quality and variety the uses of plastic in most downstream processes has generated the research in polymer blends. According to Horak *et al.* (1998), the great numbers of articles that are devoted annually to problems of polymer blends, as well as the ever-increasing quantity of various blends commercially produced, give evidence about their great importance in the field of polymer materials.

This present study focuses on the blending of polystyrene (PS) with polypropylene (PP). The PS is an amorphous polymer with a glass-transition temperature (Tg) between 90°C to 110°C, has an advantages of being clear, hard, easily processed and low cost. Because of the excellent properties described above, PS is now considered as a potential thermoplastic used for electrical/electronic, automotive, and industrial films. Although PS has many desirable properties as an engineering thermoplastic, its disadvantage is poor chemical resistance at room temperature especially to ketones [Birley, *et al.* 1992].

PP is a popular material, which has good strength and rigidity. It also possesses good chemical resistance. Thus, blending of PS with PP can be a convenient way to increase the chemical resistance of PS. PS/PP blends seem to be promising materials applicable to various purposes in packaging and for parts with improved resistance to oils in automotive industry [Horak *et al.* 1998].

However, the PS/PP blend system considered as immiscible and incompatible, because the structure of PS (contain benzene rings) belongs to the aromatic group, while PP contains straight carbon chains belonging to the aliphatic groups. It is also worth noting that PS is amorphous and brittle, while PP, is semi-crystalline and ductile. Adewole *et al.*, (2000 b) found that the resulting blends have a low impact resistance. They also suggested that the blend could be modified with the addition of rubbery toughening agents, such as an ethylene propylene copolymer (EPR) or a styrene-b-ethylene-alt-butylene-b-styrene (SEBS) tri-block copolymer. Many other researchers have also reported on the optimization of immiscible PS/PP blends through the use of styrene-butadiene-based block copolymer [Horak *et al.*, 1998, Gupta and Purwar, 1985a, Radonjic *et al.*, 1998, Hong and Jo, 2000, Hlavata *et al.*, 1999]. From previous researches, it is well known that SEBS has excellent thermal stability at high temperature and that the poly(ethylene-co-butylene)(EB) block in SEBS is compatible with PP [Horak *et al.*, 1998, Gupta and Purwar, 1985a , D'Orazio *et al.*, 1997, Radonjic, 1999, Hong and Jo, 2000, Adewole *et al.*, 2000, Mustafa *et al.*, 2001, Halimatuddahliana *et al.*, 2001]. Therefore SEBS has proven to be an effective compatibilizer for PS/PP blends, as the PS and EB block of SEBS is miscible with PS and PP, respectively.

Some recent studies involving SEBS in PS/PP blends, reported by Halimatudahliana *et. al.* (2002)], Macaubas and Demarquette (2001),and Adewole *et. al.*(2000) are devoted to: (i) the compatibilization effect of SEBS on mechanical properties of PS/PP blends; (ii) morphologies studies of uncompatibilized and compatibilized PS/PP blends; (iii) rheological studies of uncompatibilized and compatibilized PS/PP blends; and (iv) crystallization behaviour. Among the interesting finding of these studies are the improvements in ductility, compatibilization of the immiscible polymer blends and some improvements in melt rheological properties.

Others previous studies of PS/PP blends were report on the rheological behavior [Gupta and Purwar, 1985a, Fujiyama, 1996, Hong and Jo, 2000, Adewole *et al.*, 2000 a, Macaubas and Demarquette, 2001] and mechanical properties [Horak *et al.*, 1998, Gupta and Purwar, 1985b, Radonjic *et al.*, 1998, Hong and Jo, 2000, Adewole *et al.*, 2000 b, Mustafa *et al.*, 2001]. However, no study on chemical resistance of PS/PP blends has been reported in the literature so far. This present study investigates the effect of presence PP and SEBS contents into PS/PP blends with the objective to enhance the chemical resistance of PS.

EXPERIMENTAL

• Materials

PS used in this study was general-purpose grade (GPPS HH-30). Petrochemicals (M) Sdn. Bhd. supplied these resins. PP used was polypropylene homo-polymer TITANPRO 6531 with a specified melt flow index of 3.5 g/10 minutes and was supplied by Titan Himont Polymers (M) Sdn. Bhd. Both of these resins are originally in the form of extruded pellets. The compatibilizer used in this study was thermoplastic elastomer SEBS (Kraton 1652G) (containing PS blocks (Mw = 7,500) and an EB mid-block segment (Mw =37,500) and Hardness, Shore A, 30s:75) supplied by Shell, Tiram Kimia Sdn. Bhd.

• Methodology

This testing was carried out according to ASTM D543-87. The purpose of this test is to investigate changes in mass and appearance of the PS/PP blends when the specimens (refer to blends formulations, Table 1) were immersed in chemical reagent. The specimens were placed in appropriate containers for the reagents being used, and allow the specimens to be totally immersed in fresh reagent for 7 days in the Standard Laboratory Atmosphere.

Throughout the investigation, Acetone and Tetrahydrofuran (THF) were used in this test because they are ketone and ether groups. Acetone with concentration of 100% also listed as recommended chemical reagent in standard test method for resistance of plastics to chemical reagents.

The preferred test duration was 1 week for a standard test (particularly at room temperature, 25°C $\pm$ 2 °C). Following standard scale changes in mass and appearance was reported at 24 hours, 96 hours and 168 hours. Immediately after immersion, specimens were rinsed and wiped, and specimen's weight was reported to the nearest 0.001 g. Five tests were carried out for each blend sample. For each specimen, the percentage of mass difference by was calculated by the following formula:

$$(m_2 - m_1)/ m_1 \times 100$$

where;

m_1 = weight before immersion

m_2 = weight immediately after immersion

Table 1: Blends Formulations

SAMPLE DESIGNATION				
No	CODE	Composition (phr %)		
		Rigid Component (%)		Compatibilizer (%)
		GPPS (HH-30)	Homo PP (6431)	SEBS (Kraton 1652G)
1	Control-1	100	0	0
2	Control-2	0	100	0
3	Control-3	90	10	0
4	PS90-1	90	10	5
5	PS90-2	90	10	10
6	PS90-3	90	10	15
7	PS90-4	90	10	20
8	PS90-5	90	10	25
9	Control-4	80	20	0
10	PS80-1	80	20	5
11	PS80-2	80	20	10
12	PS80-3	80	20	15
13	PS80-4	80	20	20
14	PS80-5	80	20	25
15	Control-5	70	30	0
16	PS70-1	70	30	5
17	PS70-2	70	30	10
18	PS70-3	70	30	15
19	PS70-4	70	30	20
20	PS70-5	70	30	25
21	Control-6	60	40	0
22	PS60-1	60	40	5
23	PS60-2	60	40	10
24	PS60-3	60	40	15
25	PS60-4	60	40	20
26	PS60-5	60	40	25

RESULT & DISCUSSION

- **Resistance to Acetone**

Figure 1 shows the swelling effect of the various PS/PP blend samples after immersion in acetone for 24, 96 and 168 hours. This swelling effect is represented by the percentage of weight increase after the immersion.

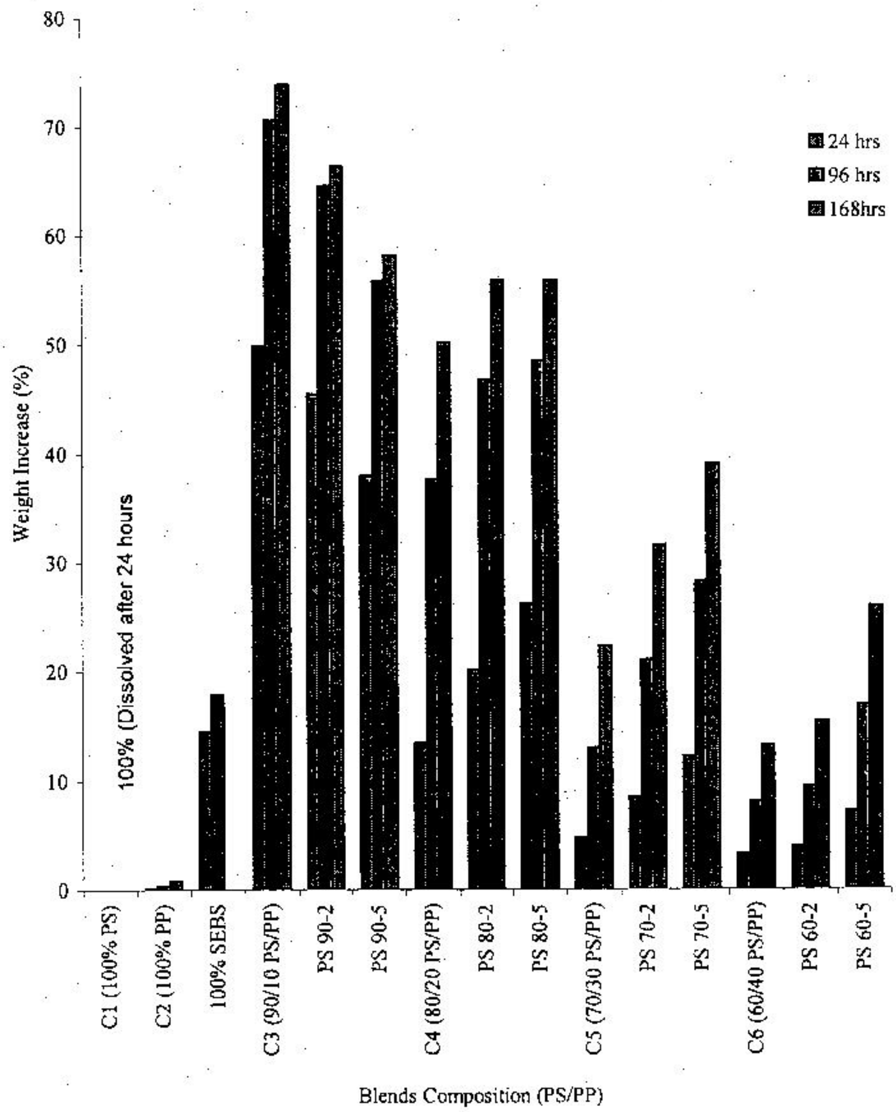


Figure 1: Swelling effect of various PS/PP blends samples after immersion in acetone

PS was found to dissolve after immersion in acetone for more than one hour, which confirmed that PS has chemical weak obstacle towards ketone's group. Pure SEBS increases by about 18% weight after 96 hours immersion in acetone. The weight change in PP after immersion in acetone is only minimal (<1%) which indicates that PP has a good resistance to ketone's group. Figure 2 shows no dimensions change and swelling effect occurred to PP samples during and after immersion.

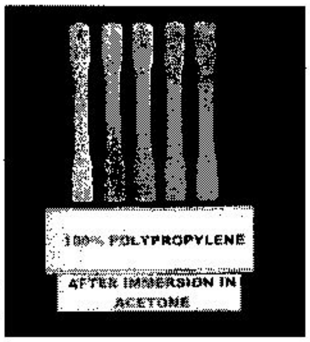


Figure 2: PP samples after immersion in acetone.

From Figure 1, it can also be seen that dramatic weight change occurred for all blends composition upon increasing the time of immersion from 24 hours to 168 hours. This clearly indicates that chemical resistance of polymers decrease with time. The uncompatibilized 90/10 PS/PP blend shows the highest percentage of weight increase than the other blends composition whereby the weight increases by 78 % after 168 hours. Higher PS contents and low degree of compatibility causes this phenomenon to occur. The result also shows that the chemical resistance of the PS/PP blends increases with increasing PP content as expected.

The weight increase in the 90/10 PS/PP blend was reduced when 10 % SEBS was added into the blend. A further increase of SEBS content from 10 to 25 % reduces the weight increase from 60 to 40 %. The weight increase was reduced because increasing SEBS content, which has better resistance to acetone than PS. The other probable factor is the increased compatibility between PS and PP with the presence of SEBS.

In contrast, for the 20, 30 and 40% PP content in the PS/PP blends, an increment in weight was observed with increasing SEBS contents. This is because the ratio of PP in the blend decreases with increasing SEBS content. PP was found to be superior than SEBS in the resistance to acetone. The nature of PP may also be modified due to the interaction with SEBS, which reduced the crystallinity content. The other possible reason is the samples is being modified by PS due to the increased compatiblity between PP and PS with the presence of SEBS

Figure 3 displays the percentage of loss weight occurred after PS/PP blend samples immersion in acetone for 168 hours. This determination of loss weight was done after drying process. The drying process takes long time to achieved consistent weight of PS/PP blend samples. The long durations of drying process is probably due to some of acetone was trapped in PS/PP blend samples. Weight loss being determined indicates the amount of the polymer dissolved in the chemical.

Similar to the results on the swelling effect, PP is better than PS in resisting the attack from acetone. PP lost only 0.16% of the weight after the drying process as compared to PS, which totally dissolved. It was also observed that the weight loss for SEBS is around 60%. Figure 3 illustrates the trend of PS/PP blends weight loss effect is similar to the swelling effect, whereby the chemical resistance increases with PP content. This observation was proven by photograph of 60/40 PS/PP blends in Figure 4, where less surface distortion occurred on that blend samples. Only a little change on the dimension and weight of that blend samples was observed.

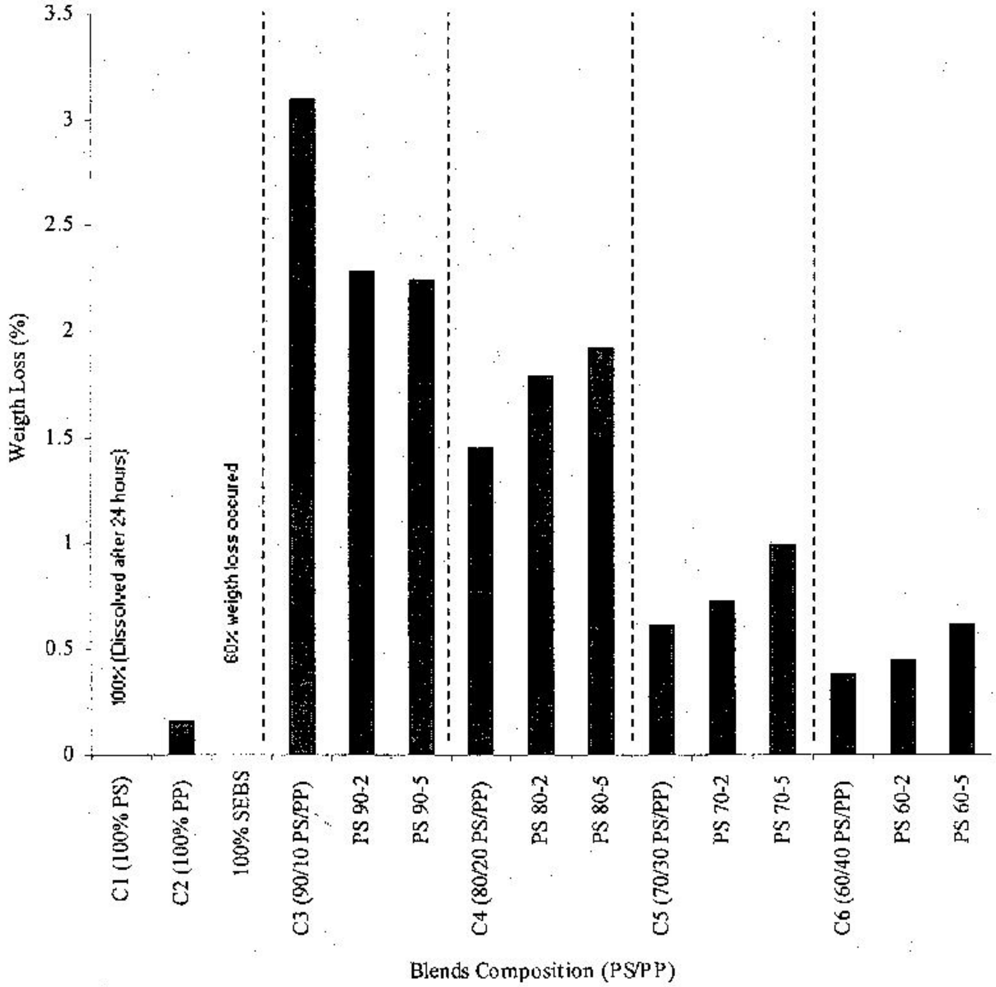


Figure 3: The loss weight effect after immersion in acetone for 168 hours

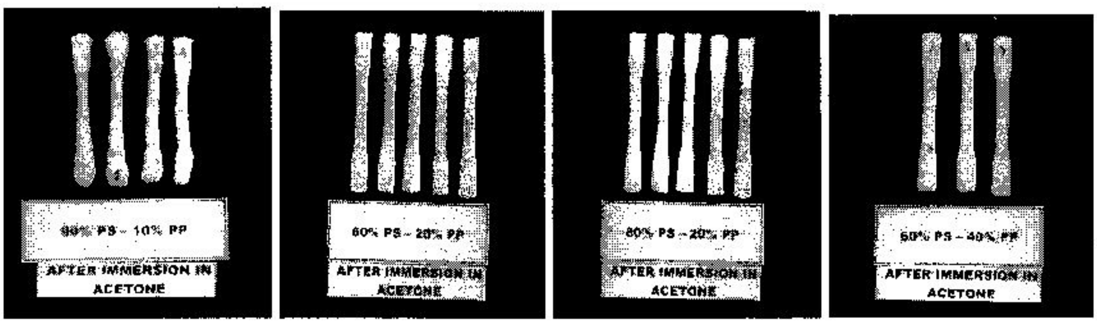
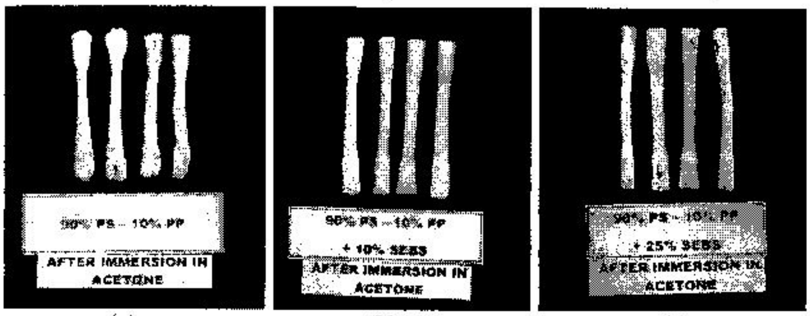


Figure 4: The effect of PS/PP blends composition on resistant to acetone

The effect of SEBS on the weight loss of PS/PP blends is also shown in Figure 3. The result in the Figure 5 shows that only the 90/10 PS/PP blends improve upon the incorporation of 10 phr of SEBS. No significant improvement occurred with further increase of SEBS from 10 to 25 phr. The photographs in Figure 5 show the extent of distortion after the drying process of the 90/10 PS/PP blend. It is clear that the surfaces distortions occurred is more severe in the uncompatiblized blends compared to compatibilized blend with SEBS.

However, in the in blends with 20, 30, and 40 % PP content, increasing SEBS contents decrease the chemical resistance. This is because as previously mentioned SEBS also has poor resistance to acetone whereby about 60 % weight loss observed as shown in Figure 3.



(a) (b) (c)

Figure 5: The effect of SEBS contents in 90/10 PS/PP blends; (a) uncompatibilized, (b) 10 phr SEBS and (c) 25 phr SEBS

CONCLUSION

The chemical resistance study showed that chemical resistance of PS/PP blends increases with PP content. However, the effect of SEBS depends on the PP content in the blends. For the 90/10 and 80/20 PS/PP blends, the chemical resistance increased with increasing SEBS content. On the other hand, for 70/30 and 60/40 PS/PP blends, the chemical resistance decreased with increasing SEBS content.

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