MECHANICAL PROPERTIES OF HIGH IMPACT ABS/PC BLENDS – EFFECT OF BLEND RATIO

Azman Hassan and Wong Yean Jwu

Department of Polymer Engineering, Faculty of Chemical and Natural Resources Engineering
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor Bahru.

ABSTRACT

Polymer blends are capable of providing materials which extend the useful properties beyond the range that can be obtained from single polymer equivalents. Blends of Acrylonitrile-Butadiene-Styrene (ABS) and Polycarbonate (PC) were prepared in different ratios by melt blending technique which was carried out using a twin screw extruder. A super high impact ABS at different weight ratios was incorporated into the blends to study the effects of blend ratio on the properties of the blend. This study focused upon tensile, flexural, impact and creep properties of ABS/PC blends. PC offered an improvement in tensile properties for this blend. With the increasing content of PC in ABS/PC blends, both the tensile strength and Young's Modulus of the blends were increased. Both the flexural strength and modulus show a marked increase with increasing PC content. In general, impact strength increases with increasing PC content. However, sudden drop in the impact strength value occurred when small amount of PC (20 wt%) was added to the blends. The creep resistance of neat PC exhibited the highest value while neat ABS has the lowest value. The optimum formulation for the ABS/PC blends based on the mechanical properties and cost is 40: 60 ABS/PC blend ratio.

Keywords: *Polymer blends, blending, ABS, PC, tensile strength, impact strength, creep*

1.0 INTRODUCTION

Blending of conventional polymers is a convenient way of developing materials with novel or selectively enhanced properties which are possibly superior to those of the component (Chang, 1997). The development of new polymers from polymer blends is far less costly and faster than the development of new polymers from synthesis. Furthermore, blends offer the possibility of tailor-making products to meet specific end needs. Therefore, blends are economically attractive and are experiencing significant growth (Datta and Lohse, 1996).

Acrylonitrile-butadiene-styrene (ABS) is a widely used thermoplastic. In ABS, acrylonitrile causes an improvement in chemical resistance and weatherability, butadiene has the character of rubber toughness, and styrene offers glossiness and processability. The compositions of the various components can be controlled to meet the requirements of a variety of applications. However, the overall mechanical properties of ABS are lower than those of most engineering plastics, and the heat distortion temperature of general grades of ABS is lower than 100°C (Ping, 1998, Chin and Hwang, 1987). In order to upgrade the use of ABS, one simple way is to blend ABS resin with other high performance engineering plastics such as polycarbonate (PC). Blends of PC and ABS have been commercially available for a number of years. PC can contribute towards improvements in strength, dimensional stability, heat distortion temperature and impact resistance of the blends. On the other hand, ABS provides processing advantages, chemical resistance besides cost reduction with respect to PC. Therefore, the purpose of ABS/PC blends is the modification of properties and performance with respect to the neat polymers. It is hope that this blend will have a better balance of properties at a cheaper cost. The objective of the present study is to investigate the effects of blends composition upon mechanical properties of super high impact ABS/PC blend.

2.0 EXPERIMENTAL

2.1 Material

Emulsion grade, super high impact ABS resin with a specified melt flow index of 14 g/10 min (at 220ºC and 10 kg load) was supplied by Toray Plastics (Malaysia) Sdn. Bhd. PC with melt volume flowrate of 11 cm^3/10 min (at 300 ºC and 1.2 kg load) was supplied by Bayer. Both were originally in the form of extruded pellets.

2.2 Preparation of polyblends of ABS and PC

The polycarbonate and acrylonitrile-butadiene-styrene was delivered in the form of pellets. First of all, PC was dried in a circulation oven at 120 °C for 8 hours whereas ABS was dried for 6 hours at 85 °C prior to blending in order to remove moisture before processing. The basis of formulation was based on the percentage weight ratio between ABS and PC. The outline of different weight ratios of blends are shown in Table 1.

Table 1: Blends Formulations

Blends	Formulation	
	PC (wt %)	ABS (wt %)
B1	0	100
B2	20	80
B3	40	60
B4	60	40
B5	80	20
B6	100	0

Later these blends were mixed in a tumbler mixer for 5-10 minutes to form a uniform composition throughout the batch size. This uniformly mixed feed was then melt blended in a co-rotating twin-screw extruder at a speed of 200 r.p.m. and the temperature profile adopted during compounding of all blends was 220/230/240/250°C for the barrel zone temperatures. The extruded strands were air-dried and pelletized. Injection moulding was done at a zone temperature profile of 210-240 °C.

2.3 Materials characterization

2.3.1 Tensile Testing

Samples were cut according to ASTM D638 type 1 specimen dimensions. The machine that was used for the testing of tensile properties is Universal Testing Machine (Lloyd UTM L1000S). The test was conducted at velocity 50 mm/min at ambient temperature (28^{o}C). Five specimens of each formulation were tested and the average values were reported.

2.3.2 Flexural Testing

Flexural Test was also conducted using Universal Testing Machine (Lloyd UTM L1000S). according to ASTM 790. For testing, the support span was fixed at 100 mm and the rate of crosshead motion at 3 mm/min. Five specimens of each formulation were tested and the average values were reported.

2.3.3 Impact Testing

The Izod Impact Machine was used for this testing, where the specimen is clamped vertically as a cantilever beam so that the notched end of the specimen is facing the striking edge of the pendulum. The dimensions of the sample specimens conform to ASTM D256. Five specimens of each formulation were tested and the average values were reported.

2.3.4 CreepTesting

The test specimens for the creep test have similar dimensions to specimens used in tensile test. Two 5 mm diameter holes were drilled at both ends of the test specimen with their centers at a distance of 10 mm and 22.5 mm respectively from the end and 10 mm from the sides. On each end of the specimen, two 30 mm x 20 mm x 2.5 mm steel tabs with two 5 mm diameter holes in the center of the tabs were attached on each side. Two threaded bolts each measuring 5 mm in diameter and 15 mm in length were passed through the steel tabs and holes and then tightened with nuts to ensure that firm grip exist between the steel tabs and the specimen. One end of the specimen was tied with a rope to a beam and thus the specimen was suspended from the beam while the free end of the specimen was attached with steel plates with a 5 mm diameter hole for suspending a known constant weight. Load was applied by suspending large steel plates with 20 kg weight from the specimen by means of a rope.

A span length of 50 mm was marked on each specimen and the elongation was monitored and recorded daily using suitable measurements. The creep strain for a given day of testing is calculated as:

$$\textit{Creep strain} = \frac{L_t - L_0}{L_0} x100\%$$

where, L_t = Strain after t days of loading

L_0= Strain at the instance of loading

3.0 RESULTS AND DISCUSSION

3.1 Tensile Properties

3.1.1 Effect of PC Content on Tensile Strength and Young Modulus

Both tensile strength and Young Modulus increased with increasing PC content in the ABS/PC blend (Figure 1). From Figure 1, it was observed that the tensile strength increased almost linearly with the increasing of PC ratio in the ABS/PC blends. Similar observation was also reported in Wei and Hwang (1999) study which stated that tensile strength increased with the increasing PC contents in ABS/PC blends. In addition, Young Modulus showed a significant improvement from 1752 MPa to 1953 MPA when 20 wt% PC was added into the blends as compared to pure ABS. However, Young Modulus was observed to increase slightly between 20 wt% to 80 wt% PC. It was found out that between this range, there was only a 2.6% increment in the Young Modulus.

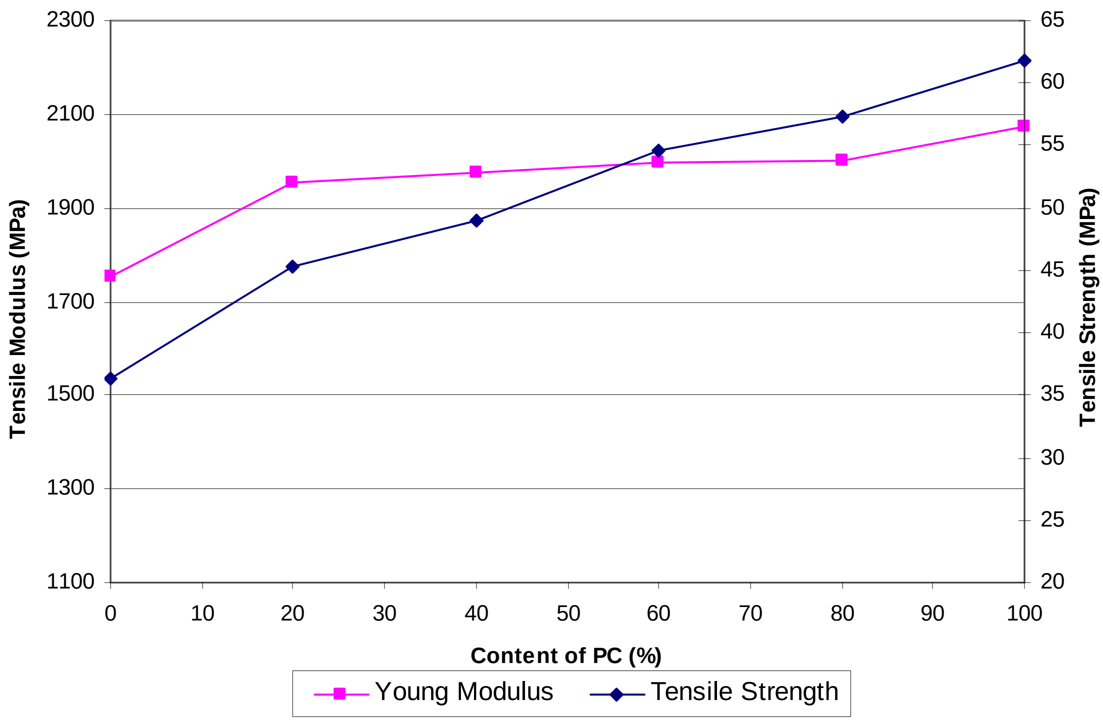

Figure 1: Effect of Blend Ratio on Tensile Properties of ABS/PC blends

3.1.2 Effect of PC Content on Elongation at Break

Figure 2 shows the effect of PC content on the elongation at break for ABS/PC blends. It was found that initially, the elongation at break drops to the lowest value (5.2%) when 20 wt% PC was incorporated into ABS/PC blends. This is followed by a marginal increment of 8.6% between 20 wt% to 60 wt% PC. However, a mark increase of elongation at break value (37.5%) is detected beyond 60 wt% PC. Generally, elongation at break for ABS/PC blends increased with the increasing of PC contents in the blends.

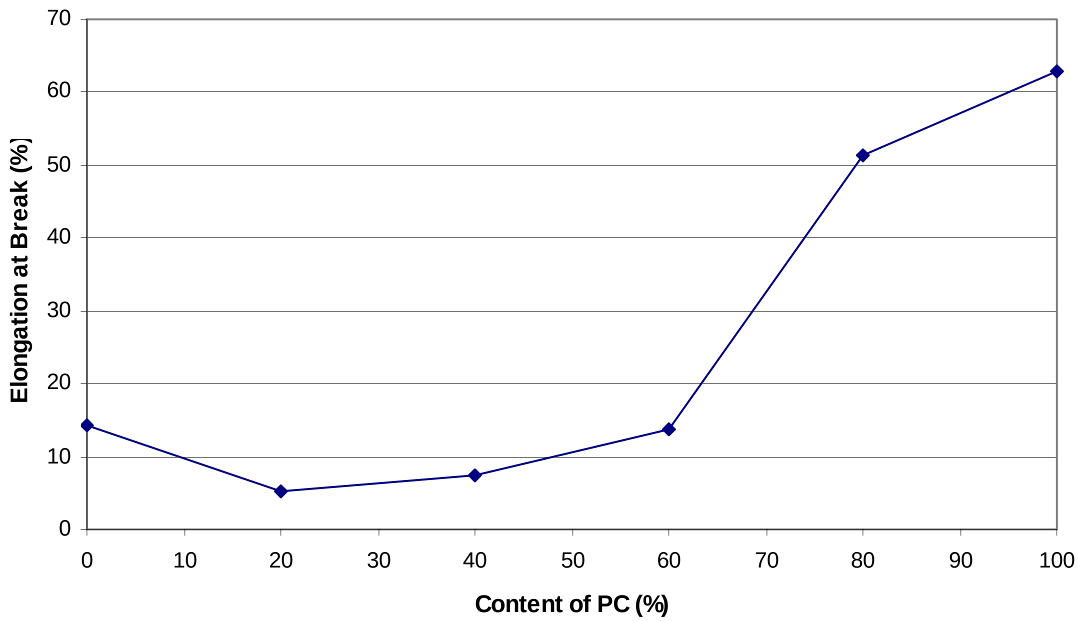

Figure 2: Effect of Blend Ratio on Elongation at Break of ABS/PC blend

The overall results from tensile studies confirmed that PC, being an engineering plastics has superior properties in all three aspects that is stiffness, strength and ductility over ABS. The properties in general improved with increasing PC content in the blends.

3.2 Flexural Properties

3.2.1 Effect of PC Content on Flexural Strength and Flexural Modulus

Figure 3 shows the effect of PC content on the flexural strength and flexural modulus of ABS/PC blends. Overall, it was observed that the flexural modulus and flexural strength of the blends increased with the increasing of PC contents into the ABS/PC blends. This result agrees with the result of Wei and his coworkers who reported that blending ABS with PC will improve the flexural properties of the blends. As shown in Figure 3, the flexural strength values increased linearly up to 60 wt% PC content and then followed by a marginal increase of flexural strength from 73.8 MPa at 60 wt% PC to 75.0 MPa at 80 wt% PC. However, significant improvement in flexural strength was observed beyond 80 wt% PC added into the blends. From Figure 3, it can be seen that flexural modulus also showed a similar trend as flexural strength, where increasing PC contents will increased the flexural modulus of the blends. This is expected because neat PC have higher flexural modulus then neat ABS.

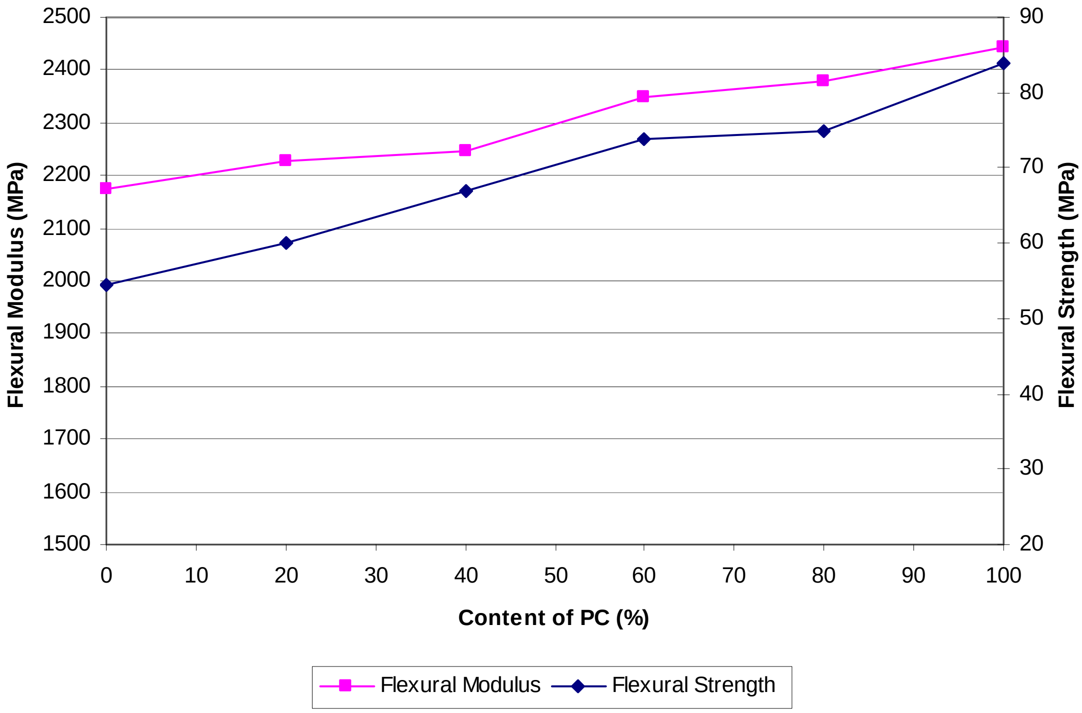

Figure 3: Effect of Blend Ratio on Flexural Properties of ABS/PC blend

3.3 Impact Properties

3.3.1 Effect of PC Content on Impact Strength

Figure 4 gives the notched Izod impact strength of ABS/PC blends. This figure clearly illustrates that the incorporation of PC into ABS showed a positive blending effect on impact strength on the whole range of composition. However, an interesting observation has been made where a sudden drop in the impact strength value occurred when small amount of PC (20 wt%) was added to the blends. At this point, the high impact resistance character of PC did not offer any improvement in impact resistance of ABS/PC blends. Similar results had been reported by Wei and Hwang (1999) and Suarez *et al.*(1999) who stated that the addition of PC in ABS generally will increase the impact strength of the ABS/PC blends but with an inflection occurred in ABS enriched ABS/PC blends. It is interesting to observe that in ABS/PC blends¸ the impact strength of the blend at the region of PC content less then 40 wt% was lower than that of pure ABS. However, at PC content beyond 40 wt%, the impact strength of the blend started to increase proportionally with the PC content in ABS/PC blends. Pure PC showed the best impact properties among all the blends.

Theoretically, in ABS morphology, the butadiene rubber particles are dispersed in the SAN phase. Adding minor PC in ABS formed triple phase morphology: SAN continuous phase, dispersed butadiene rubber particles in SAN and PC particles in SAN. However, as PC content increased, it gradually became the continuous phase in the blend whereas ABS particles were then dispersed in the PC continuous phase. The result shows that if the PC remains as disperse phase, it was not effective in initiating yielding in the SAN continuous phase. On the contrary, when ABS was in disperse phase it was relatively more effective in initiating yielding and increased the impact resistance of the blends

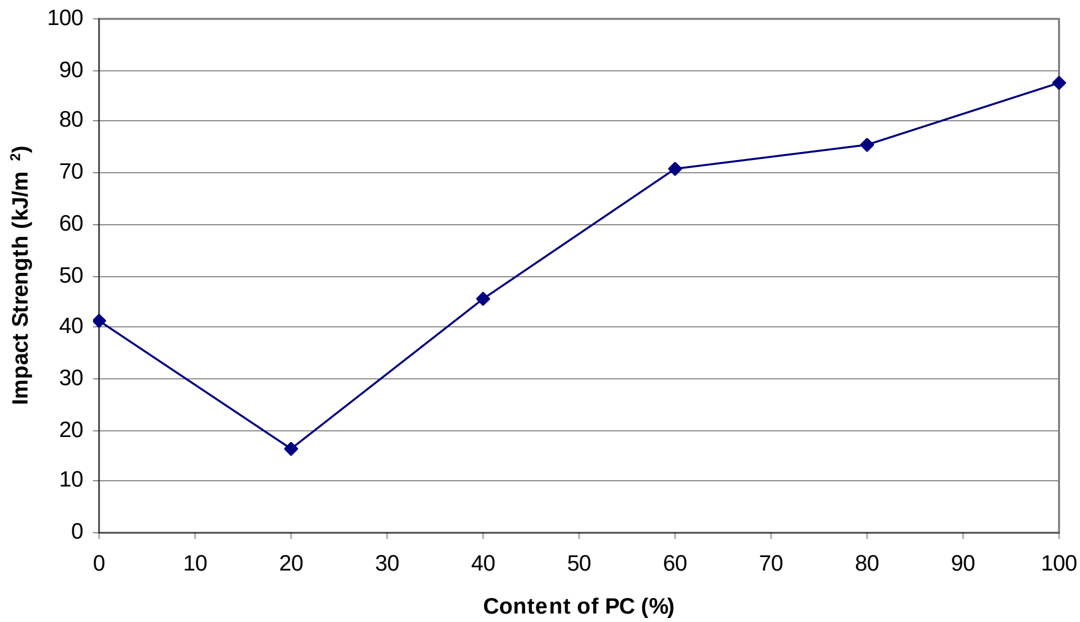

Figure 4: Effect of Blend Ratio on Impact Properties of ABS/PC blend

3.4 Creep Properties

3.4.1 Effect of PC Content on Creep Resistance

Figure 5 shows that with the increasing of PC content in ABS/PC blends, the strain for the blends became lower. The creep strain value for pure ABS is the highest among six formulations which reached 0.81 % while pure PC has the lowest strain value (0.33%). From Figure 5, it is observed that a remarkable decrease in the strain value occurs when 60 wt% PC is added to the ABS/PC blends. The explanation to this phenomenon is that within 40 wt% to 60 wt% PC in ABS/PC blends, there is a phase transition from ABS continuous phase to PC continuous phase. When PC is the continuous phase, the blends exhibits higher creep property then ABS continuous phase. This result is similar to Johnny, E.B (2000) study which stated that pure PC specimen exhibits higher creep property then pure ABS specimens. However, these results are based on a single specimen test for each specimen and further test need to be carried out with additional samples in order to get a more accurate result.

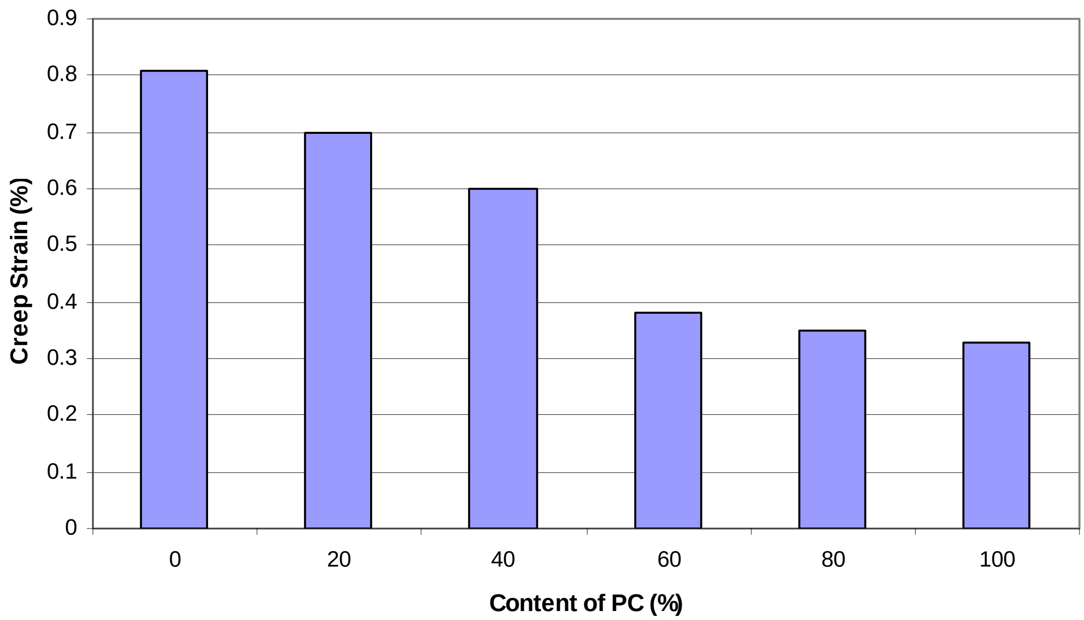

Figure 5: Effect of Blend Ratio on Creep Resistance of ABS/PC blend

4.0 CONCLUSIONS

The objective of the present study is to investigate the effects of blends composition upon mechanical properties of super high impact ABS/PC blend. Based on the results, the following conclusions can be made:

i) Both tensile strength and Young Modulus increased with the increasing of PC content in ABS/PC blend. With the increasing of PC content in ABS/PC blends, elongation at break for ABS/PC blends generally increased.
ii) The overall trend shows a marked increase in flexural strength and flexural modulus with increasing of PC content.
iii) The impact strength increased significantly with the addition of PC contents in ABS/PC blends. A good impact resistance was obtained only when PC was the continuous phase in the blend.
iv) Generally, the creep strain decrease with the increasing of PC content. This means that pure PC exhibits better creep property compared to pure ABS.

v) The optimum properties for ABS/PC blends are observed when 60 wt% PC was incorporated into the blends.

5.0 REFERENCES

Chang, F. C. 1997. Compatibilised thermoplastic blends. Handbook of thermoplastics Ed. Olagoe Olabisi, New York. Marcel Dekker. pp 61-84.

Chin, W. K., and Hwang, J. L. 1987. Modification of ABS properties by Additions of Polycarbonates (PC) and Nylon 6. *Chem Systems INC*. Vol 303; 587-592.

Datta, S. and Lohse, D. J. 1996. Polymeric compatibilisers uses and benefits in polymer blends. New York. Hanser Publishers, pp 191-193, 317-319.

Johnny, E.B 2000. Mechanical Property Characterization of Recycled Thermoplastics. University of Morgantown, West Virginia: Degree of Master of Science Thesis.

Ping L. Ku. 1998. Polystyrene and Styrene Copolymers: Their Manufacture and Application. *Advances in Polymer Technology*. Vol. 8; 201-223.

Suarez, H., Barlow, J. W. and Paul, D. R. 1984. Mechanical Properties of ABS/Polycarbonate Blends. *Journal of Applied Polymer Science*. Vol 29; 3253-3259.