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THE EFFECT OF BLENDING ACRYLIC GRAFTED PVC AND PVC K-66 WITH ABS ON IMPACT AND FLEXURAL PROPERTIES

CHEW SAU YEN[1], AZMAN HASSAN[2] & SHAHRIR HASHIM[3]

Abstract. Blends of acrylonitrile butadiene styrene (ABS) and poly(vinyl chloride) (PVC) were studied. The blends were prepared in different ratios by melt blending technique. High rigidity, medium impact and super high impact ABS were used as the base polymer. Acrylic grafted PVC and PVC K-66 were incorporated into the blends. Particular emphasis was on Izod impact test. The impact strength of the blends increased with increasing content of PVC. Interestingly, the result shows that the highest impact strength occurs when acrylic grafted PVC was added into super high impact ABS. However, it was observed that when PVC is incorporated in ABS, there is a decrease in the flexural modulus. The least decrease occurred when PVC K-66 was added into high rigidity ABS. These observations are consistent with the morphological studies. Scanning electron microscopy (SEM) revealed that an increase in PVC content results in greater ductility.

Keywords: ABS, PVC, impact strength, flexural modulus, SEM

Abstrak. Adunan antara ABS dan PVC telah dikaji. Adunan yang mempunyai pelbagai nisbah ini disediakan dengan teknik pengadunan leburan. ABS yang mempunyai ketegaran tinggi, hentaman yang sederhana dan hentaman paling tinggi digunakan sebagai polimer dasar. Manakala, PVC bercangkuk akrilik dan PVC K-66 ditambah ke dalam ABS. Ujian hentaman Izod dititik-beratkan. Kekuatan hentaman adunan meningkat berikutan dengan peningkatan berat molekul PVC. Yang menariknya, kekuatan hentaman yang paling tinggi wujud apabila PVC bercangkuk akrilik diadunkan bersama ABS berhentaman paling tinggi. Walau bagaimanapun, penurunan modulus lenturan berlaku apabila PVC ditambah ke dalam ABS. Penurunan modulus lenturan yang paling minimum ialah adunan antara PVC K-66 dan ABS bertegaran tinggi. Keputusan yang diperolehi adalah serasi dengan pemeriksaan morfologi. Mikroskopi imbasan elektron (SEM) menunjukkan semakin tinggi kandungan PVC, semakin tinggi kekuatan hentaman.

Kata kunci: ABS, PVC, kekuatan hentaman, modulus lenturan, SEM

1.0 INTRODUCTION

The formation of a polyblend is one means of achieving certain specific properties which are difficult to obtain from any one of the simple components alone [1]. It has often been assumed that blend development is far less costly and time consuming than the development of new polymers and therefore blends are economically attractive

[1,2&3]Department of Polymer Engineering, Faculty of Chemical and Natural Resources Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor Bahru.

[2]. Nevertheless, blends offer the possibility of customising products to meet specific end needs. These advantages of polymer blending on performance and economy have accelerated R&D activities in the field of polymer blends in terms of academic and industrial interest.

Acrylonitrile butadiene styrene (ABS) is one of the most widely used of the rubber toughened commercial plastics. It has been characterised as two phase system, a blend of polybutadiene rubber phase and styrene acrylonitrile copolymer (SAN) rigid phase. ABS is found in an extensive range of applications because of its excellent balance of mechanical properties, processing latitude, recyclability and economics. It can be further blended with other materials, thus the scope of possible applications is broadened [3].

PVC is derived partly from petrochemicals and partly from common salt; its price tends to remain relatively stable since it is partially insulated from oil-price fluctuations. The PVC used in this research are PVC K-66 and acrylic grafted PVC. Acrylic grafted PVC is a suspension graft copolymer of vinylchloride and an acrylate elastomer. This grafted polymer makes it possible to produce finished products offering higher impact strength without adding modifier.

When poly(vinyl chloride) (PVC) and ABS are mixed, it is probable that PVC interacts easier with the SAN phase than with the rubber phase considering their respective polarities. When blended with ABS, the result is a material with good impact strength, toughness and inherent flame resistance [4].

In this research, the ABS, which is the major component, will become base polymer and PVC, which is the minor component, is the added polymer. The objective of this study is to develop new materials with better impact properties by optimising blend compositions of different grades of ABS and PVC.

2.0 EXPERIMENTAL PROCEDURE

2.1 Material

ABS resin, emulsion grade with high rigidity, medium impact and super high impact PVC K-66 and acrylic grafted PVC were supplied by local vendors. The manufacturer has the proprietary right on the ratio of ABS monomer and the range of elastomer content in acrylic grafted PVC.

Thermolite T890 was used as tin stabilizer. Calcium stearate, Sak-Cs and stearic acid, Hst was added as an internal and external lubricant respectively.

2.2 Preparation of Polyblends of ABS and PVC

ABS was dried by using hopper dryer. Weighed amounts of PVC, tin stabilizer and lubricants were thoroughly mixed in a laboratory mixer for 14 minutes. The dry blend was then mixed mechanically with dried ABS and followed by melt blending in a

40 mm Tanabe single screw extruder at a zone profile of 185°C and 110 rpm. Extrudates were quenched in water and palletised. Injection moulding was done at a zone temperature profile of 170–185°C.

2.3 Mechanical testing

Mechanical properties were determined by using the Izod pendulum impact tester and flexural Instron tester. Notched Izod impact strength was measured according to ASTM D 256A test method using pendulum type. Three-point bend flexural testing was conducted with an Instron Universal testing Machine Series XI according to ASTM D790.

2.4 Microscopy

Scanning Electron Microscopy (SEM) observations were carried out using the normal and backscattered electron modes (Jeol, JSM-5610) to determine and analyse impact fracture surfaces. The JFC-1600 auto fine coater was used to coat the surface of the specimens with a thin layer of conductive gold.

3.0 RESULTS AND DISCUSSION

3.1 Impact strength

Figures 1 and 2 show that the impact strength increases with increasing PVC content in the PVC/ABS blends for both types PVC. The results also show that for pure ABS, the super high impact grade has the highest impact strength values as expected since it has the highest butadiene rubber content. This is followed by the medium impact grade and the high rigidity grade is the lowest. It is interesting to observe that as the PVC content increases, the super high impact grades shows the highest increment.

Similar trend is seen in both types of PVC. In the PVC/super high impact grade ABS, the acrylic grafted PVC shows a higher increment of 65% as the PVC content increases from 0 to 20 phr compared with only 63% for the K-58 (refer to Table 1). The reason is acrylic grafted PVC, which is a grafted polymer of vinyl chloride and acrylic elastomer, with some level of elastomer is produced to withstand higher impact load. Basically, the elastomer content of acrylic grafted PVC is higher than PVC K-66. When blended with different types of ABS, acrylic grafted PVC will show higher impact strength.

The addition of PVC, results in a synergistic effect that is the impact strength is higher than either pure ABS or PVC. The impact strength for unfilled PVC obtained by Sivaneswaran [5] is 9 kJ/m^2. Other researchers also supported that PVC has a lower impact strength compared with ABS [6]. The possible reason for this effect is that the addition of PVC into ABS enhances the ductility of the matrix thus increasing the

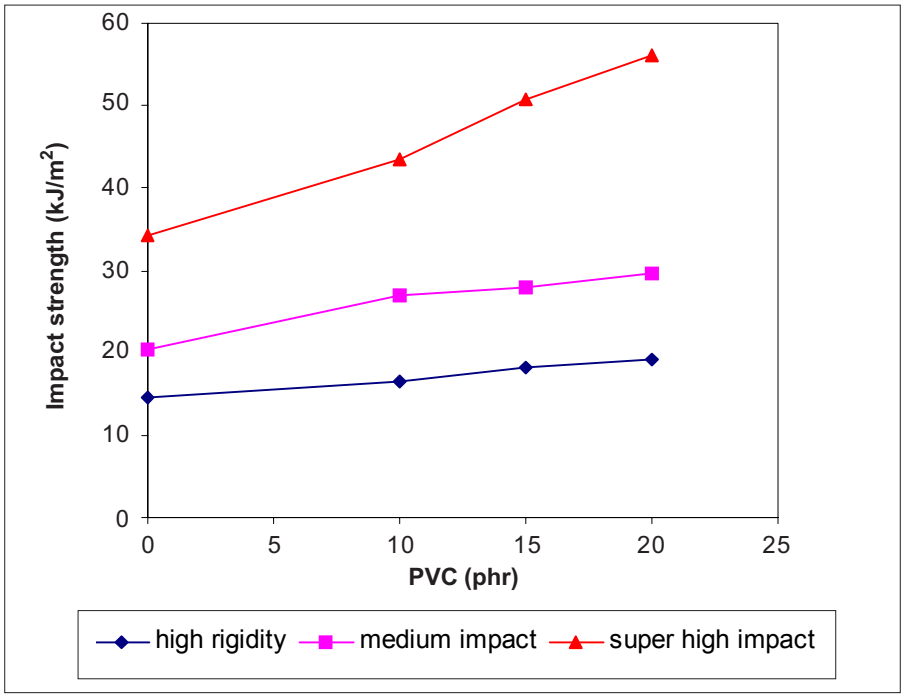

Figure1 Effect of PVC K-66 on impact strength of different grade of ABS

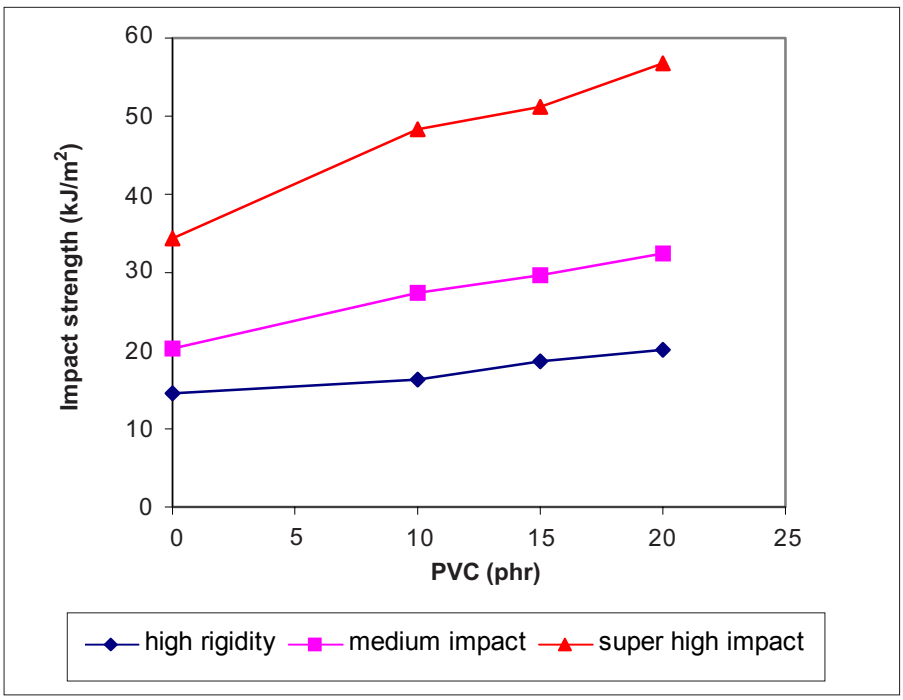

Figure 2 Effect of acrylic grafted PVC on impact strength of different grade of ABS

Table 1 Effect of 20 phr PVC on impact strength of ABS/PVC blends

ABS	PVC K-66 Increment (%)	Acrylic grafted PVC Increment (%)
Super high impact	63	65
Medium impact	45	60
High rigidity	31	38

amount of energy being absorbed. In ABS polymer, SAN forms the matrix phase and butadiene is the discrete phase which acts as a stress concentrator. The yielding in the SAN matrix phase is relatively difficult due to the presence of benzene molecule. The addition of PVC modifies the matrix phase since PVC is believed to be miscible with SAN [7]. This may be explained in terms of solubility parameter of both polymers. The solubility parameter *d*, a measure of attractive forces between molecules, may be used to determine the miscibility. According to the data given by Bramfitt and Heaps [8], SAN has a solubility parameter of 19.6 $MPa^{1/2}$ whereas solubility parameter for PVC is 19.4 $MPa^{1/2}$ [8]. The difference of these two polymers is 0.2. According to Svec *et al.*, [9], the difference in solubility of two polymer must be lesser than 0.4 if the polymers are miscible. Therefore, SAN/PVC fulfilled the criteria. Hence, addition of PVC into SAN matrix will form a new matrix phase which is a combination of PVC and SAN. The presence of PVC will promote shear yielding for the blend and thus increase the impact strength. The strong interfacial adhesion of the SAN matrix with PVC results in the increase in impact strength and toughness.

3.2 Flexural Properties

Figure 3 shows that the flexural modulus decreases with increasing PVC content in the PVC/ABS blends for both types PVC. The result also shows that for pure ABS, the high rigidity grade has the highest flexural modulus values. As expected, the highest styrene content provides the stiffness to the blends. This is followed by the medium impact grade and the super high impact grade is the lowest. It is also observed that as the PVC content increases, the super high impact grade shows the largest reduction. From Figure 3, it can also be seen that in general, the flexural modulus of the ABS/PVC K-66 are higher than the ABS/acrylic grafted PVC. This is due to the higher elastomer content with low rigidity in acrylic grafted PVC. The decrease of flexural modulus due to the addition of 20 phr PVC into the blends is summarised in Table 2. The results show that the reduction for the high rigidity grade and medium impact is relatively small. It is expected that super high impact ABS, which has the highest content of elastomer has the lowest flexural modulus.

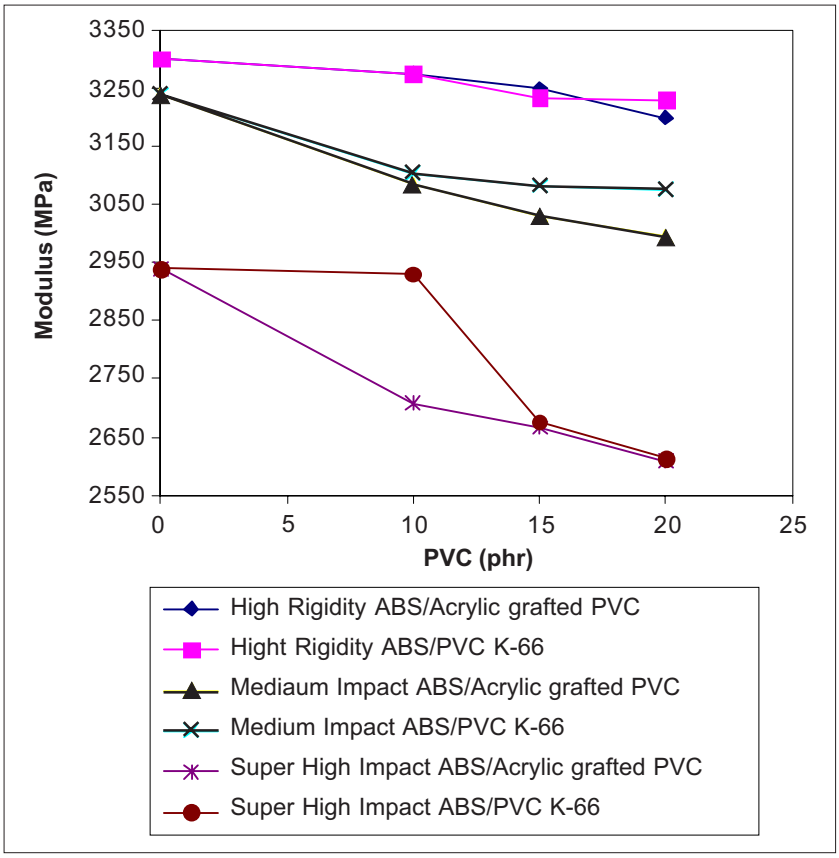

Figure 3 Effect of PVC types and ABS grades on flexural modulus

Table 2 Effect of 20 phr PVC on flexural modulus of PVC/ABS blends

ABS	PVC K-66 (% reduction)	Acrylic grafted PVC (% reduction)
Super high impact	11	11
Medium impact	5	7
High rigidity	2	3

3.3 Scanning Electron Microscopy Studies

Scanning Electron Microscopy was used to determine the surface roughness, which can be correlated to the fracture energy. This study is not intended to compare the fracture surface with the types of ABS and PVC. Figure 4 shows the SEM micrograph of impact-fractured surface of high rigidity ABS that has impact strength around 14 kJ/m^2. The micrograph shows a scaly and typical flat surface with the micro characteristics

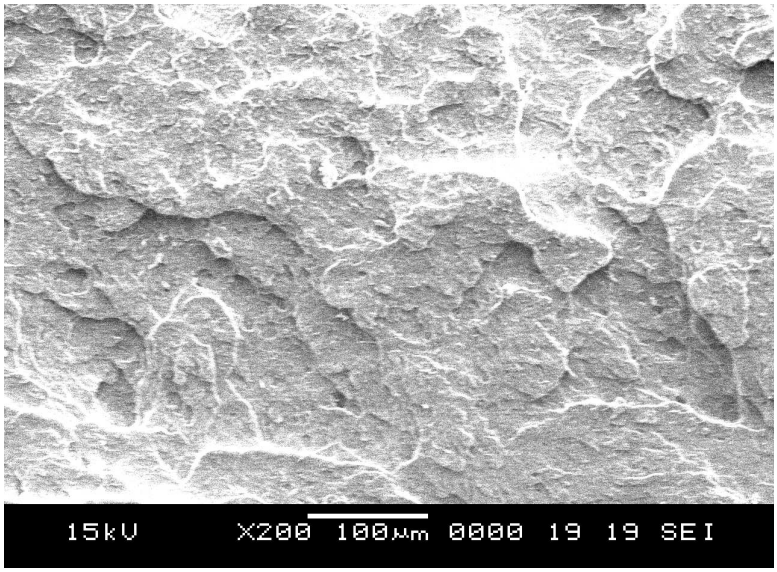

Figure 4 SEM micrograph of fracture surfaces of high rigidity ABS

typical of a rigid and glassy surface. Figure 4 shows the zoom of this fracture surface where it spread into several planes.

The fractured surface of 80/20 super high impact ABS/ acrylic grafted PVC (shown in Figure 5) is relatively rough and coarse, probably due to plastic deformation and tearing during fracture process [10]. The parabolic multiple fracture surfaces with flow

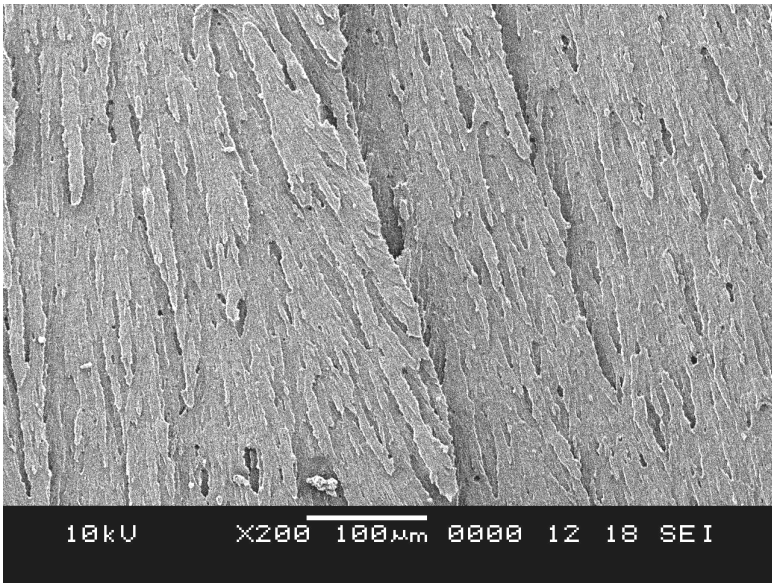

Figure 5 SEM micrograph of fracture surfaces of 80/20 super high impact ABS/acrylic grafted PVC blends

of ridges are associated with rubber particles at focal points. Formation of multiple fracture surfaces with furrows seen under SEM is considered an additional energy absorption mechanism because it can be seen in tough plastics [11]. The surface roughness and stress whitening is much higher compared with virgin high rigidity ABS shown in Figure 4.

4.0 CONCLUSIONS

The conclusions that can be derived from the study are impact strength increases with increasing PVC content in the PVC/ABS blends for both types PVC. The possible reason for this synergistic effect is that PVC enhanced the ductility of the matrix thus increasing the amount of energy being absorbed. As the PVC content increases, the super high impact grade shows the highest increment in impact strength. The acrylic grafted PVC is proven to be more effective in enhancing the impact strength of ABS. Flexural modulus decreases with increasing PVC content in the PVC/ABS blends for both types PVC. As the PVC content increases, the super high impact grade shows the largest reduction. The flexural modulus of the ABS/PVC K-66 is higher than the ABS/acrylic grafted PVC. Scanning electron microscopy reveals that incorporation PVC in ABS shifted the surface morphology to become more rough and ductile, indicating enhancing toughness.

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