THE MECHANICAL PROPERTIES OF NYLON 6 (PA6)/ACRYLONITRILE-BUTADIENE-STYRENE (ABS) BLENDS

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ABSTRACT

Blending is a combination of two or more polymer to produce a new polymer which has good mechanical properties at low cost. Nylon 6 and ABS both have their specialty and weakness but on the other hand, with the combination of Nylon/ABS, it helps to patch both weaknesses. For this study, high impact ABS was used to blend with PA 6 to improve the mechanical properties and to reduce the cost. The main purpose of this study was to investigate the ratio of PA 6/ABS blends to produce a good combination of mechanical properties such as tensile, flexural and impact properties. Besides, the study was also investigate the compatibility of PA 6/ABS and to examine the structure morphology of its blends. For sample preparation, the pellets of PA 6 and ABS were extruded at the different composition using twin screw extruder and then being moulded using injection moulding machine. In this study, the tests conducted were tensile test, flexural test, Izod impact test and morphology examination of PA 6/ABS blends. With the increasing of ABS content in PA 6/ABS blend, the tensile strength, tensile modulus and elongation at break were decreased. Besides, the flexural strength and flexural modulus of the blend were also decreased. However, the addition of ABS increased the Izod impact strength of the blend. The best ratio for the PA 6/ABS blends based on the mechanical properties is 60:40 PA 6/ABS.

Keywords
PA 6, ABS, polymer blends, mechanical properties

INTRODUCTION

Nowadays, most of the daily requirements are made from plastic such as table, chair, toy and others. Not only at home, plastics used are general. The ever-increasing use of plastics in civilized society is now recognized as a significant contributory factor to an increased standard of living. Plastics are used for almost everything from the articles of daily use to the components of complicated engineering structures and heavy industrial applications.

With the growing of the demand of plastic materials, engineering plastics has been introduced. However, engineering plastics like Nylon 6 (PA6), have relatively poor fracture toughness levels when compared to another classes of materials like metals and ceramic [1]. Here, the toughening mechanism is believed to improved the fracture toughness as well as increases the capacity to absorb energy before rupture [2].

PA6 is in a major class of engineering plastics [3,4]. as it possesses good balances of several properties-good chemical resistance, good wear and abrasion resistance, and good mechanical and thermal properties [5]. PA6, however, has some drawbacks associated with its processing instability high mold shrinkage and dimensional instability-due to its inherent properties of rapid crystallization and high

water affinity. Acrylonitrile-butadiene-styrene copolymer (ABS), on the other hand, has some strength [6-9] over PA6 in high water resistance, low mold shrinkage, and high cost competition, even if other mechanical and thermal properties are not so good as of PA6. Blending of ABS with PA6, thus, may offset the drawback of each :polymer, leading to a variety of commercial application such as interior parts in the automobile, wheel covers, ski boots, helmets, motor housings, etc
.

In order to improve the application of PA6, blending the PA6 with other engineering plastic such as ABS is a best alternative and has been used to modify some of the PA6 properties [10-27]. ABS obtains a higher strength, better toughness, greater stability and other properties. Impact resistance and toughness are the most outstanding mechanical properties. Consequently, the reason of PA6/ABS blend is to modify the properties and performance with respect to the base polymer. It is expect that this blend will have a better balance of properties.

In this investigation, it has been attempted to evaluate the synergistic effect of mechanical properties of the blends of PA6 and ABS and optimize the blends compositions by determining the mechanical properties and morphology. Optimal blend compositions associated with the desired mechanical properties may be obtained from this study, and it is expected to be one of fundamentals for the further reactive blending study and optimal processing of commercial product.

EXPERIMENTAL

Material

PA 6 with the grade of Amilan CM1017 was supplied by Toray Plastics (Malaysia) Sdn. Bhd. High impact ABS also was supplied by Toray Plastics (Malaysia) Sdn. Bhd. with a specific, elt flow index of 15 g/10 min (at 220°C and 10 kg load). Both were originally in the form of extruded pellets.

Preparation of PA 6/ABS

Firstly, the PA 6 and ABS pellets was dried in a dryer at 80°C for 24 hours to remove a moisture. This is an important step before processing. The weight ratios of blends are shown in Table 1.

Blends	**Formulation**	
	PA 6 (wt.%)	**ABS (wt.%)**
S1	100	0
S2	80	20
S3	60	40
S4	40	60
S5	20	80
S6	0	100

Table 1: Blend Formulation

The pellets of PA 6 and ABS were prepared according to Table 1. Then, it was melt blended in a counter-rotating twin screw extruder. The extrusion was conducted at speed of 45–50 r.p.m. and at a barrel temperature of 190, 210 and 230°C from feeding zone to die zone, respectively. The extruded pellets of these blends were dried at 80°C for 4 hours before .

Material Testing

Tensile Test

Tensile test was performed according to ASTM D638. The testing was carried out using the High Performance Tensile machine (INSTRON 5567). The crosshead speed of the testing was employed at 50 mm/min and ten specimens of each formulation were tested and only five specimens the average values were recorded.

Flexural Test

Flexural test was carried out according to ASTM D790, three-point loading utilizing center loading system. This test was carried out on a High Performance Tensile machine (INSTRON 5567). The distance between the spans is 48 mm and the rate for crosshead motion was fixed at 3 mm/min for all specimens. Ten specimens have been used for this testing but five samples are test for each composition and average values were recorded.

Impact Test

Test method according to ASTM D256-02 cover to measure the relative susceptibility of specimen to the pendulum-type impact load. The impact test was done using Izod Impact Tester (LS-22009). The pendulum hammer with angle of 150°and the weight of 2.76 kg are used based on the standard.

Scanning Electron Microscope (SEM)

The morphology of PA 6/ABS blends have been analyzed by Scanning Electron Microscope (SEM). The blends were first freeze fracture under liquid nitrogen to make sure the surface for examination was really flat. The cryogenically fractured surfaces were etched in a formic acid to remove the PA 6 phase. The fracture surfaces were coated with a thin layer of gold prior to SEM examination.

RESULTS AND DICUSSIONS

Tensile Properties

Figure 1 shows the effect of ABS content on the tensile properties of PA 6/ABS blends. The tensile properties of PA 6/ABS blends decreased with the increase of ABS ratio in the blends. . It shows that tensile strength decreased slightly from 84.6 MPa to 73.6 MPa with the increment of 20 wt.% of ABS content. The addition of 20 wt.% to 80 wt.% of ABS content, the tensile strength of PA 6/ABS blends decreased almost linearly.

As a tensile strength of PA 6/ABS blends, the Young's modulus showed decreased trend of the blends. It demonstrated that the sharply decrease in Young's Modulus when addition of 20 wt.% of ABS into pure PA 6. It was found out that the decrease was 21.4%. Then, the decreasing in Young's modulus of the blends occurred linearly until the increment of 60 wt.% of ABS content. As a result, the results showed negative blending effect on the whole range of composition.

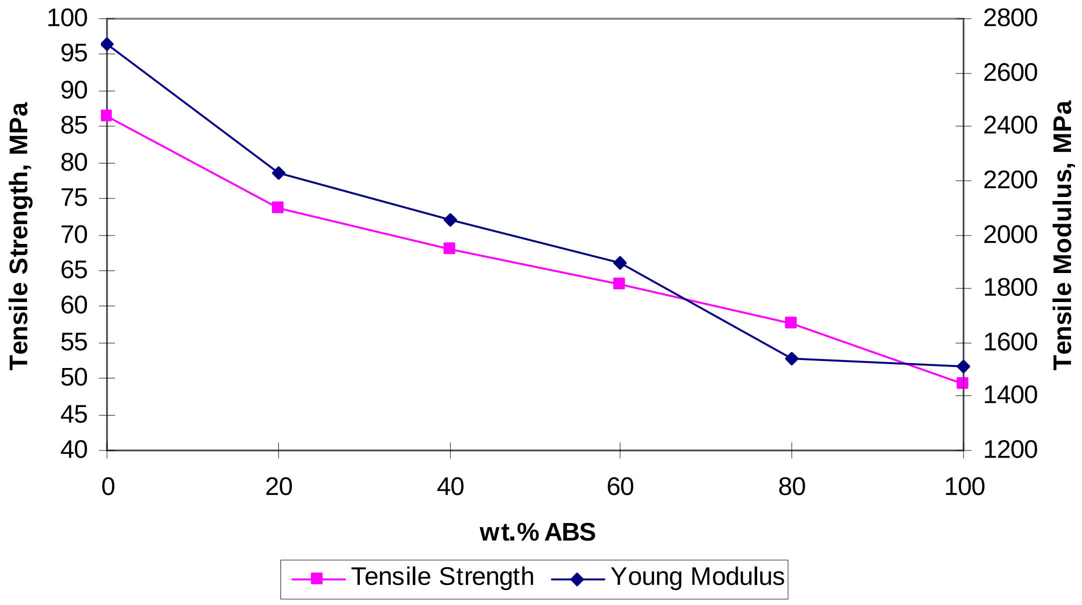

Figure 1: Effect of ABS Content on Tensile Properties of PA 6/ABS Blends

From Figure 2, it was found that the incorporation of ABS has reduced the elongation at break of PA 6/ABS blends. By adding of 20 wt.% to 40 wt.% of ABS into PA 6, the elongation at break of the blends decreased from 500 to 190 % as an elongation at break of 100 wt.% of PA 6 was 790 %. The composition which contains large of ABS domains led the blends to brittle and gave a lower elongation at break.

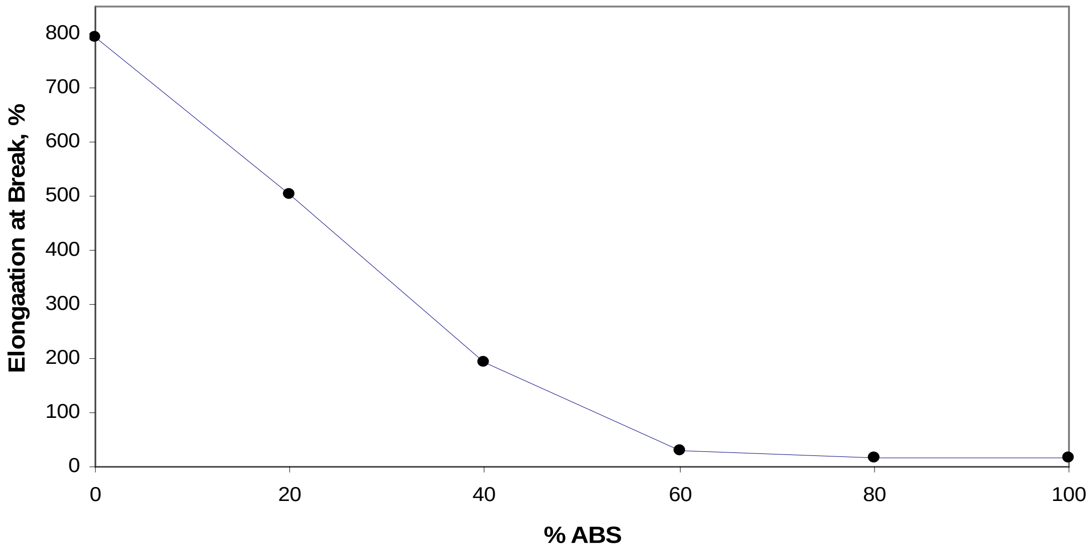

Figure 2: Effect of ABS content on Elongation at Break of PA 6/ABS Blends

Flexural Properties

Figure 3 shows the effect of ABS on the flexural properties of PA6/ABS blends. All the flexural strength values of PA6/ABS are lower than flexural strength of 100 wt.% of PA6. The values of flexural strength of the blends decreased with the increase of ABS content. Initially, the flexural strength of PA 6/ABS blends was slightly dropped from 84.5 MPa to 59.6 MPa between the addition of 0 wt.% to 80 wt.% of ABS content. Then, there was a little increment of flexural strength at 100 wt.% of ABS content. It was because the blends were attributed to the lower crystallinity of PA 6 due to the rubber addition compared with pure PA 6.

The flexural modulus showed the similar trend as flexural strength. There were a slightly decreased on the values of flexural modulus with the increment from 20 wt.% to 80 wt.% of ABS content. When ABS was added to PA 6, the rubbery phase of ABS affected the mechanical properties of the blends and thus decreased the stiffness or the flexural modulus of the blends.

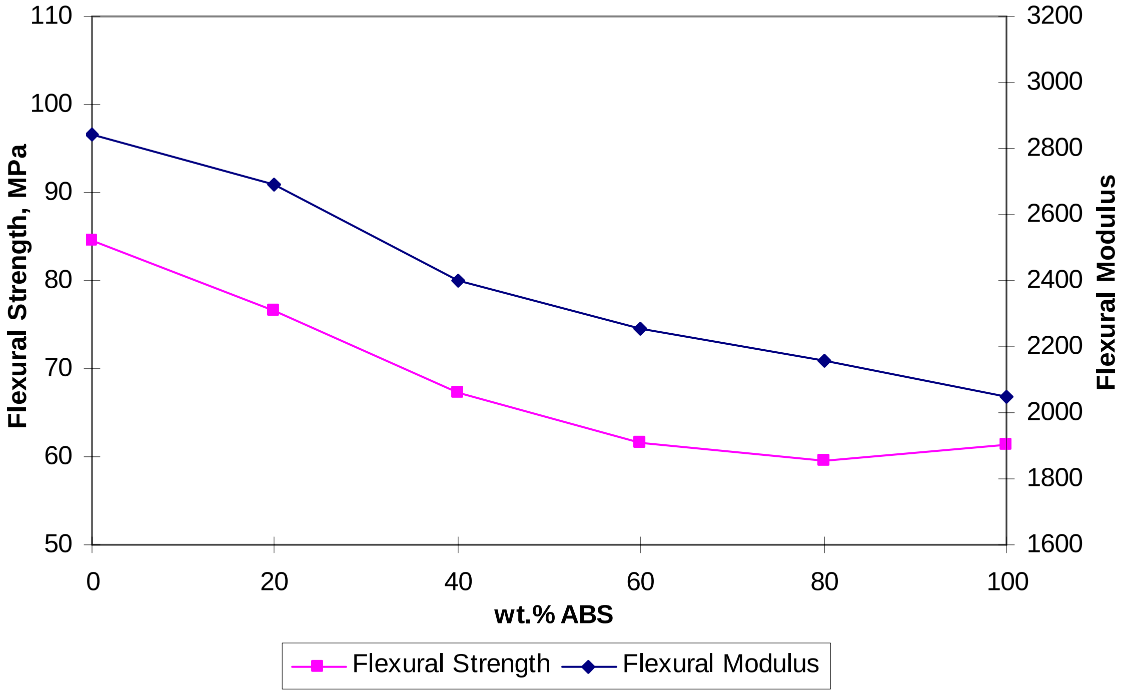

Figure 3: Effect of ABS Content on Flexural Properties of PA6/ABS Blends

Impact Properties

Figure 4 illustrates the effect of ABS content on Izod impact strength of PA 6/ABS blends. From the graph, the Izod impact strength of PA 6/ABS blends increased with the increment of amount of ABS added. ABS gives great improvement in the impact strength of the blends. When sudden load was applied on the blends, the rubbery state of the blends were absorbed the force and neutralized it. The minor addition of ABS content into PA 6 formed triple phase morphology as in ABS morphology, the butadiene rubber particles dispersed in the SAN phase. The triple phases were SAN continuous phase, dispersed butadiene rubber particles and PA 6 particles in SAN. As ABS content increased, it was then became the continuous phase in the blends while PA 6 particles dispersed in the ABS continuous phase. This was due to higher viscosity of SAN in ABS as compared to PA 6. Therefore, increased of Izod impact strength may be due to the continuous phase of ABS. This was because ABS has higher impact strength than PA 6.

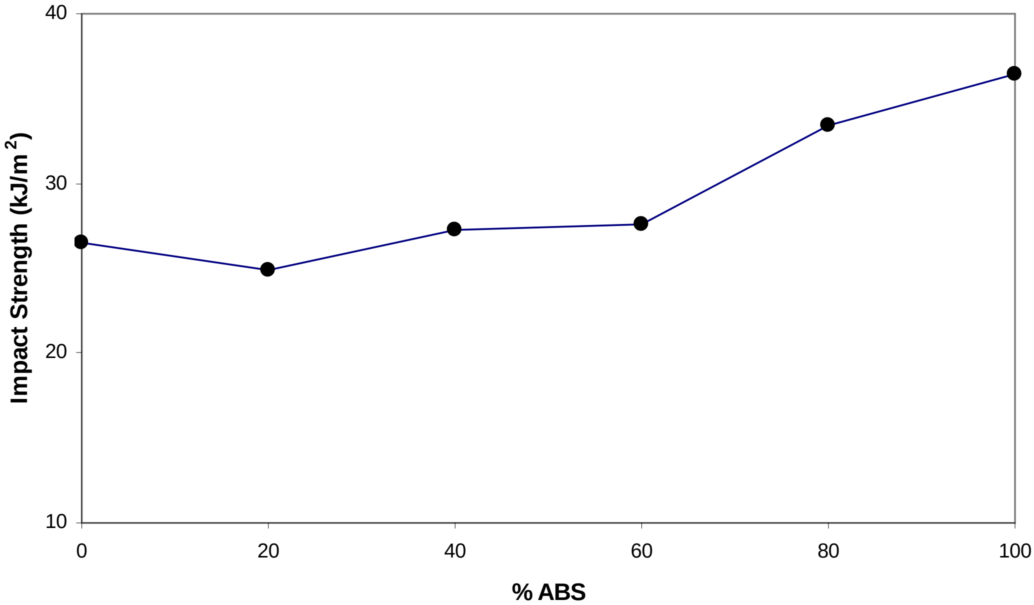

Figure 4: Effect of ABS Content on Izod Impact Strength of PA6/ABS Blends

Structure Morphology of PA 6/ABS Blends

The main physical factors that determine the final morphology of the blends are component ratio, their intrinsic melt viscosity, and rate of shear during melt mixing, and the presence of other ingredients. In this research s, the morphology of PA 6/ABS blends was analyzed by Scanning Electron Microscope (SEM). SEM micrographs of the blends are shown in Figure 5 - 8. For 20 wt.% of ABS, there was many holes occurred because of the particles of ABS leave the PA 6 phase due to weak of interfacial adhesion for both components. Since the matrix of the blend still PA 6, it performed a better mechanical strength compared with others blends. For 40 wt.% of ABS content, the particles of ABS stick well inside the matrix phase. However there were voids on the matrix surface, it still gives the best mechanical properties of the blends. The changes from ductile to brittle phase can be seen on micrograph of 60 wt.% of ABS content. Since ABS is an amorphous polymer, it gave a brittle properties and the transformation of the blend from crystalline to amorphous. That was why it have a good impact properties compared with 20 wt.% and 40 wt.% of ABS. The best morphology among the blends was 80 wt.% of ABS. There was a good interfacial adhesion between PA 6 ABS. The blend has became brittle due to matrix phase was ABS.

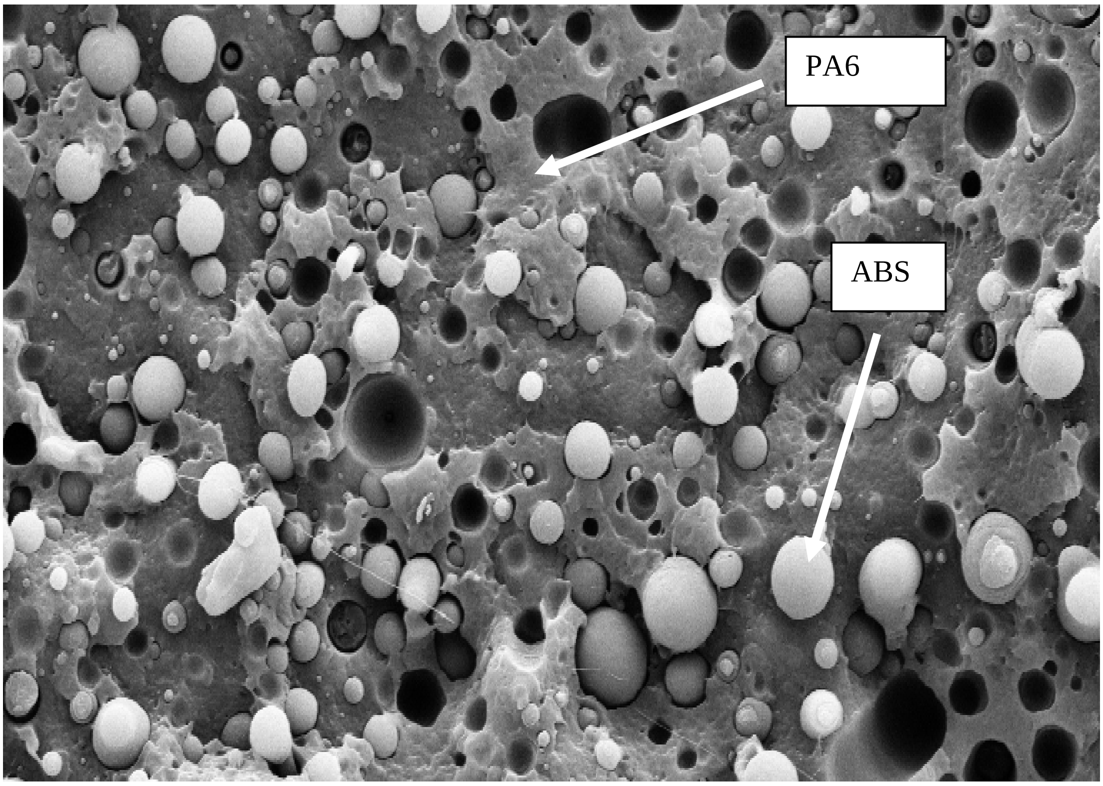

Figure 5: Micrograph of PA6/ABS Blend (20 wt.% ABS)

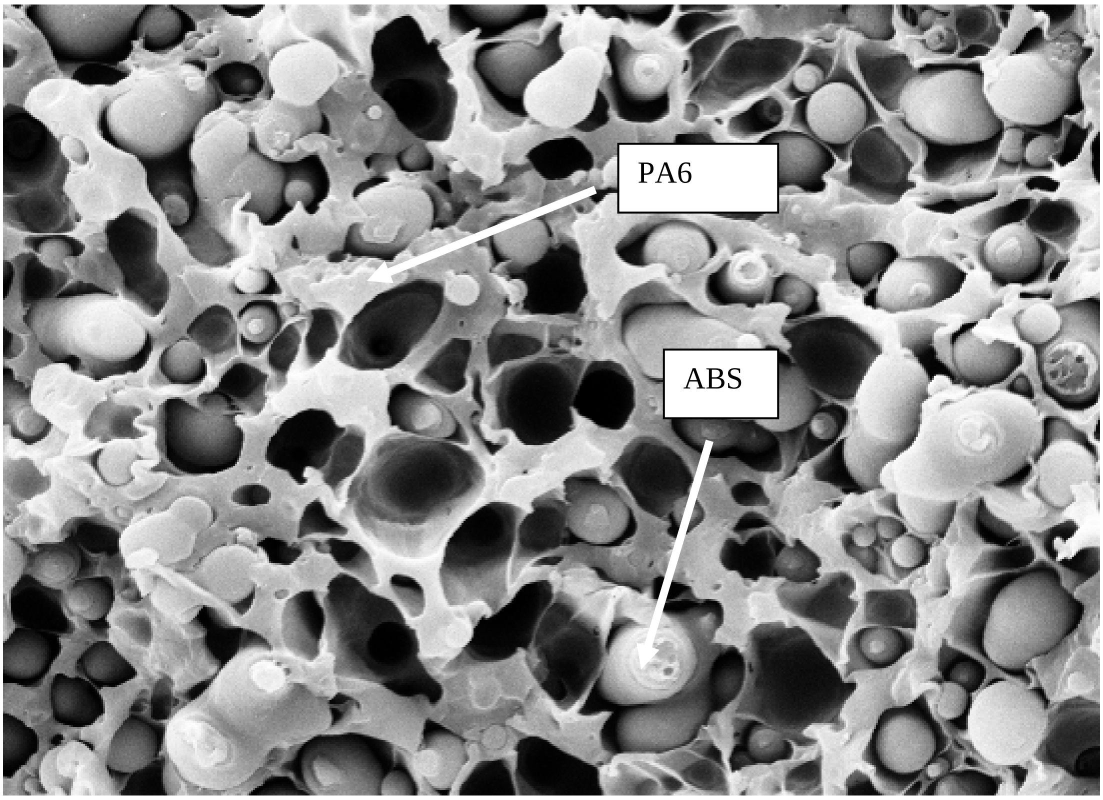

Figure 6: Micrograph of PA6/ABS Blend (40 wt.% ABS)

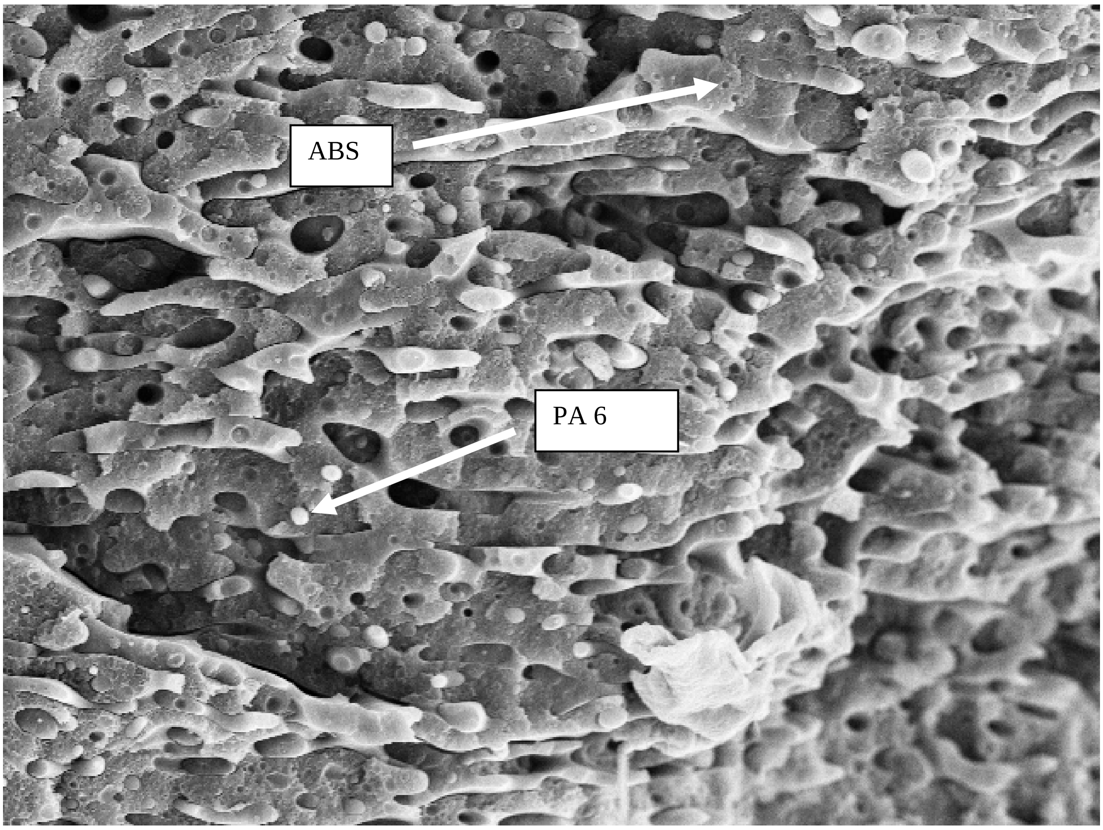

Figure 7: Micrograph of PA6/ABS Blend (60 wt.% ABS)

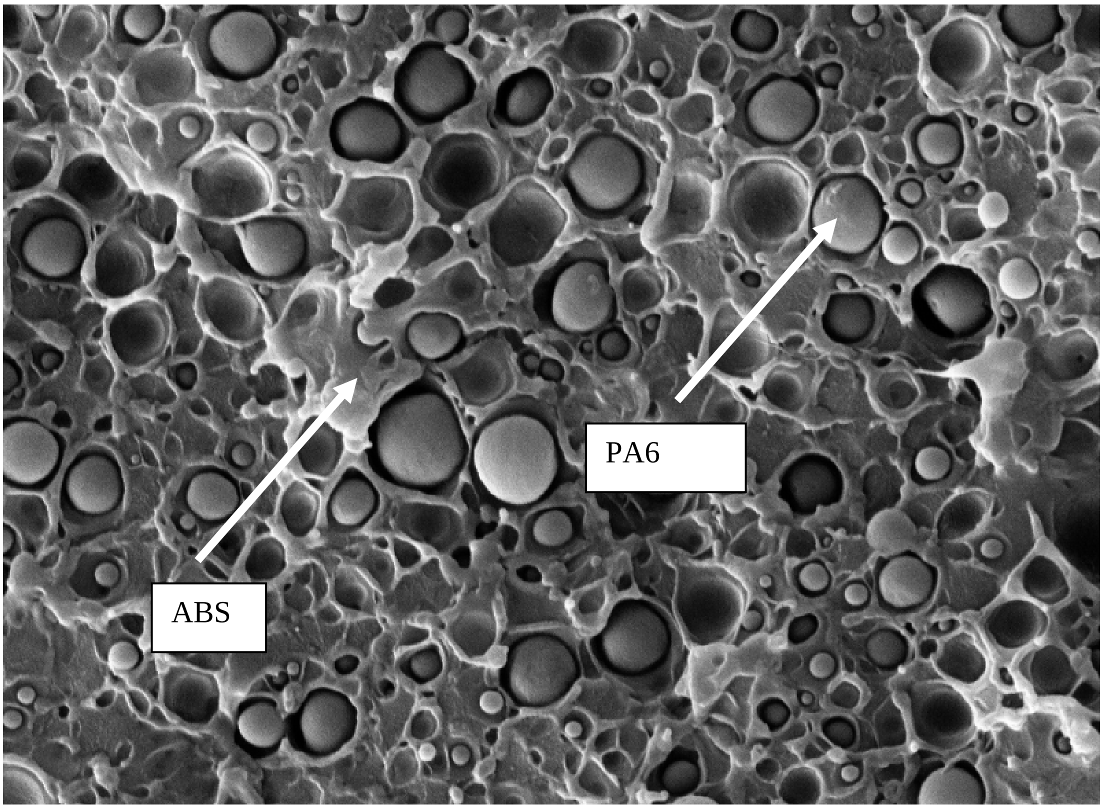

Figure 8: Micrograph of PA6/ABS Blend (80 wt.% ABS)

CONCLUSIONS

This thesis had been done to investigate the effect of blends composition upon mechanical properties of PA6/high impact ABS. From results obtained and data analyses, the following conclusion can be made:

1) Tensile properties decreased with the increment of ABS content in the blends. With the increasing of ABS in the blends, tensile strength, Young's modulus and elongation at break decreased.
2) It showed that the flexural strength and modulus also decreased due to the increment of ABS in the blends.
3) Impact properties of the blends increased with the increasing of ABS content. This is expected because neat ABS has higher impact strength than neat PA6.
4) The optimum properties of PA6/ABS blends are observed when 40 wt.% of ABS was incorporated in the blend.
5) The best morphology among the blends was 80 wt.% of ABS. There was a good interfacial adhesion between PA6 and ABS.

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