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# Enhancing the Toughness of Talc Filled Polypropylene –The Application of Ethylene Propylene Rubber as Impact Modifier

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***Abstract***–Polypropylene (PP) is a popular plastics material which is being used for injection moulding and extrusion applications. Fillers such as talc are being incorporated into PP to reduce cost and also to improve certain properties such as stiffness. However the addition of talc causes a reduction in toughness resulting in relatively brittle materials. Improvements in impact strength of talc filled polypropylene can be sought by melt blending with impact modifiers such as ethylene-propylene rubber (EPR). In this study, blends of talc filled PP and EPR were prepared in a laboratory scale extruder. The concentration of EPR was varied from 10 - 25 phr with an increment of 5 phr. After pelletising, the PP compounds were injection moulded and tested for mechanical properties. Mechanical tests such as impact, tensile and flexural were conducted to investigate the effects of EPR on mechanical properties of talc filled PP. The results show that the additions of EPR in talc filled PP decreased the Young's modulus, tensile strength, flexural modulus and flexural strength. However, EPR is found to be an effective impact modifier for talc filled PP. The optimum content of EPR in talc filled PP which gives balance of mechanical properties in terms of stiffness and toughness was found to be between 16 to 18 phr.

**Abstrak**–*Polipropilena (PP) adalah salah satu bahan plastik yang popular untuk kegunaan acuan suntikan dan penyemperitan. Penambahan bahan pengisi contohnya talk ke dalam PP akan megurangkan kos serta dapat memperbaiki sifat kekakuan. Walaubagaimanapun kehadiran talk menyebabkan pengurangan dalam kekuatan bahan disebabkan oleh bahan rapuh. Peningkatan dalam kekuatan hentaman polipropilena terisi talk dapat diperbaiki melalui pengaduan bersama pengubahsuai* *hentaman contohnya getah etilena-propilena (EPR). Dalam kajian ini, adunan PP terisi bersama-sama getah (EPR) disediakan menggunakan pengadun skala makmal. Komposisi EPR dipelbagaikan daripada 10 peratus hingga 25 peratus dengan peningkatan 5 peratus. Selepas diuntil, adunan PP disuntik dan diuji sifat mekanikalnya. Ujian mekanikal seperti ujian hentaman, tegangan dan lenturan dijalankan untuk mengetahui kesan komposisi EPR terhadap PP terisi talk. Keputusan yang diperolehi menunjukkan bahawa kehadiran EPR menyusutkan modulus Young, kekuatan tegangan modulus lenturan dan kekuatan lenturan. Walaubagaimanpun, EPR didapati adalah penguabahsuai hentaman yang berkesan untuk PP terisi talk. Komposisi optimum EPR dalam PP terisi bagi mancapai keseimbangan antara sifat kekakuan dan sifat kekuatan adalah di antara 16 hingga 18 peratus.*

Key words: (polypropylene; talc; EPR; impact strength; impact modifier)
Penambahan kekuatan polipropilene terisi talc. Kegunaan getah etilene propylene sebagai pengubahsuai hentaman

## 1. Introduction

Polypropylene (PP) is one of the important commodity polymers. The application of PP in automobiles, household appliances and the construction industry requires stiffness and toughness similar to those of engineering plastics. The application of PP, however, has been limited by its tendency to undergo embrittlement at temperatures below its glass transition temperature and low stiffness particularly at elevated temperatures. The addition of rubber would normally increase the toughness at the expense of stiffness [1]. On the other hand, the addition of filler enhanced stiffness but decreased toughness. Recently, PP has been incorporated both by elastomers and by rigid fillers in order to have a balance effect such as stiffness and toughness which is better than the neat PP [2].

Fillers such as talc are being incorporated into PP to reduce cost and also to improve stiffness and dimensional stability. In the automotive industry, specific applications for talc in polypropylene include fan shrouds, heater housings and ducts, battery heat shields, and fluid pump parts. In the appliance industry, specific applications include refrigerator door liners, heater and vacuum pump housings, and washing machine agitators.

There are several forms of ore from which talc products can be made. However, the talc of major interest to plastics users is a fine-ground product consisting of thin platelets [3]. Its low cost qualifies talc as an extender by lowering the cost of the compound and extends the resin with minimal sacrifice in physical properties. The platyness structure of talc with a high aspect ratio qualifies it to be a reinforcing filler.

Composites filled with platy talc always exhibit a higher stiffness and creep resistance, at both ambient and elevated temperatures when compared to that of composites filled with other particulate filler such as calcium carbonate [3]. A trade-off that usually accompanies high loadings of filler is reduction of impact strength. Since toughness is an important mechanical property and often the deciding factor in material selection, rubbery impact modifiers are added to compensate the reduction in impact strength. Moreover, addition of both components can offer other advantages such as reduction in cost, a good surface appearance, and improved processing behaviour.

The study on the effect of talc on PP has been an area of interest for many researchers. A study of the effects of titanate coupling agent on rheological behaviours, dispersion characteristics and mechanical properties of talc filled PP found out that tensile and flexural properties decreased whilst impact and elongation properties improved with the incorporation of coupling agent in the talc filled PP [4]. In another study, the influence of moulding conditions and talc content on the properties of PP composites were investigated. The study reported that higher mould temperatures produced densification of the amorphous phase and the subsequent modulus increase and ductility decrease, whatever the talc content [5].

In the present work, we investigated the influence of ethylene-propylene rubber (EPR). on mechanical properties, such as flexural, tensile and impact on the talc filled PP. The main objective is to determine the effectiveness of EPR as impact modifier in talc filled PP and its effect on tensile and flexural properties.

## 2. Experimental

### *Materials*

Talc Filled Polypropylene with 40 % talc content supplied by Plastrade Group of Companies was used in this study. The impact modifiers used was EPR supplied by Exxon-Mobil Chemical Company.

### *Mixing Procedures*

Pellets of talc filled polypropylene and EPR with formulation given in Table 1 were mixed in a tumbler mixer for 10-15 minutes to produce a uniform composition. The compounds were prepared using single-screw extruder with a fixed screw speed at 55 rpm. The extrudate was cooled and pelletised.

**Table 1.** Compound Formulation.

| Materials | Wt % | | | | |
|---|---|---|---|---|---|
| Talc Filled Polypropylene (%) | 100 | 100 | 100 | 100 | 100 |
| EPR (phr) | 0 | 10 | 15 | 20 | 25 |

### *Injection Moulding*

The samples for various mechanical testing were prepared using injection moulding machine. The barrel temperatures set up of 4 heating zones of the machine were as follow:

**Table 2.** Barrel temperatures set up of heating zones.

| Heater | Temperature (°C) |
|---|---|
| Feeding Zone | 200 |
| Compression Zone | 210 |
| Metering Zone | 220 |
| Die | 235 |

### *Impact Test*

Notched Izod impact test was performed using Impact Machine based on ASTM D-256-73. The injection moulded samples were notched at 45°, using a Notchvis Hand Drice cutter. A total of six specimens were tested for each composition at ambient temperature to obtain an average values.

### *Tensile Test*

The tensile test was carried out according to ASTM D638 on an Instron Universal Testing machine 5567. Dumbbell specimen was prepared according to Type I standard shape (ASTM D638). A crosshead speed of 50mm/

min was used and the test was performed at room temperature (25 ± 2°C). Tensile strength and Young's modulus were determined from the test. A total of six specimens were tested for each composition to obtain an average values.

### *Flexural Test*

The flexural test was carried out according to ASTM D-790 under a three point loading configuration. on an Instron Universal Testing machine 5567 at room temperature (25 ± 2°C). The rate for crosshead motion was fixed at 2 mm/min for all specimens and the support span was fixed at 100 mm. A total of six specimens were tested for each composition to obtain an average values.

## 3. Result and Discussion

### *Impact Properties*

Toughness is an important mechanical property and often the deciding factor in material selection. In this study, impact strength which is the energy required to break a material at a rapid loading rates was determined in Izod mode. The effect of different composition of EPR on impact strength of talc filled PP is shown in Figure 1. From the figure, the impact strength increase as the composition of EPR increases. A sharp increase in impact strength was observed typically between 15 to 20 phr content of EPR. Stress whitening is also observed at the fracture surfaces of the samples containing 15 to 20 phr of EPR, indicating the formation of multicraze. Similar result was also reported by Elinor et al. on their study on PP?EPR blend [6].

The large different of modulus that exist between rubbery impact modifier particles i.e. EPR and the polymer matrix in the blend produced significant stress concentrator sites in the blend. These localised concentrations of stress when dispersed throughout the polymer matrix provide multiple weakness sites at which shear yielding and/or crazing of the polymer can be initiated simultaneously upon impact. The result is a structure with a large number of small crazes and/or shears bands instead of a structure with a small number of large crazes or shear bands that is more prone to failure. Through facilitating the shear yielding and/or crazing of the polymer matrix, an impact modifier can compensate for the decreases in impact strength caused by the incorporation of other additives such as fillers and heat modifiers [7, 8].

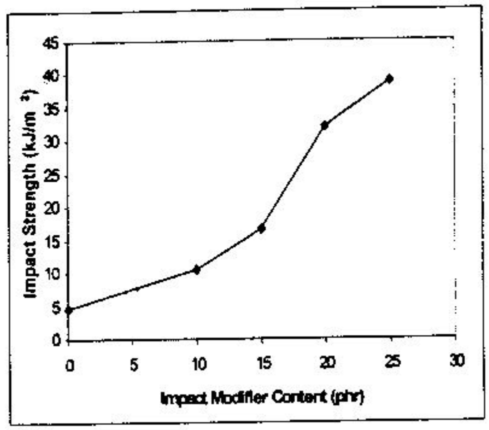


Figure 1. Impact strength versus composition of EPR.

### *Tensile Properties*

Figure 2 shows that Young's modulus of the blends decrease gradually with increasing EPR content. The tensile strength also decreases as the EPR content increases, as shown in Figure 3. Similar trend was also reported in other rubber-toughened blends which mainly attributed to the softening effect of the rubbery component which has lower modulus and strength [6]. This drop in the tensile strength indicated a weakening of the material with the increase in EPR content. As the EPR concentration

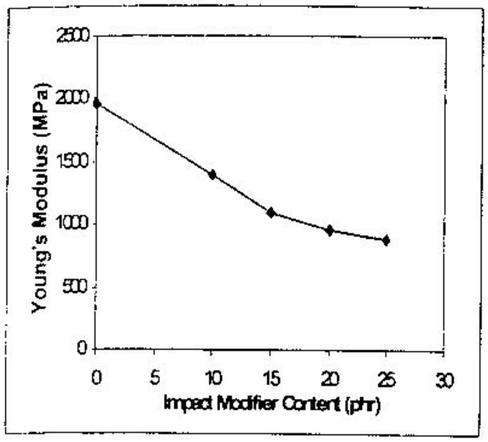


Figure 2. Young's modulus versus composition of EPR.

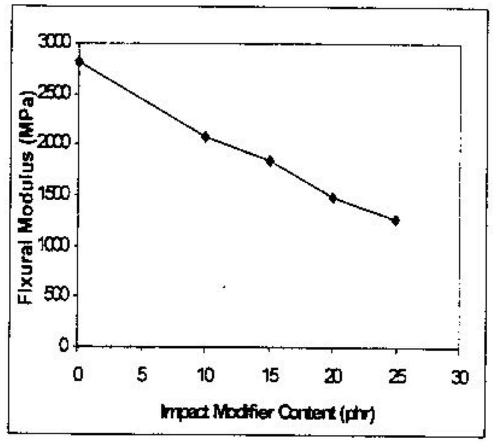


Figure 4. Flexural modulus versus composition of EPR.

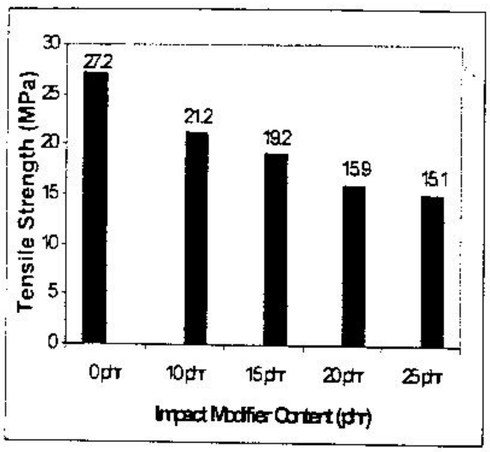


Figure 3. Tensile strength versus composition of EPR.

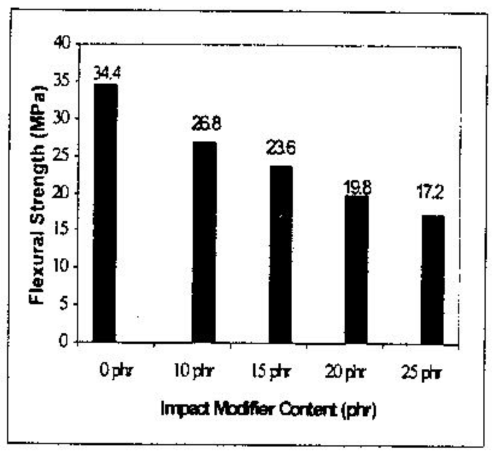


Figure 5. Flexural strength versus composition of EPR.

increases from 0 to 25 phr, the Young's modulus and tensile strength decrease by 55% and 45 % respectively.

### *Flexural Properties*

Flexural testing was carried out to determine the rigidity of the rubber-toughened composites. Figure 4 and 5 illustrate the dependent of flexural properties on the EPR content in the ternary blend composites. As expected, an increment of EPR concentration led to a gradual reduction in flexural strength and flexural modulus. As the EPR concentration increase from 0 to 25 phr, the flexural modulus decrease from 2817 to 1259 MPa, presenting a 55% reduction of the original value. The reduction in the flexural modulus indicated a softening of the material with the increase of EPR content. With a similar increase in EPR content, the flexural strength decreased by half.

### *Determination of Optimum Content*

One of the most important aspects in the development of engineering thermoplastics is to achieve a good combination of properties at a moderate cost. As far as mechanical properties are concerned, the main target is to strike a balance of stiffness, toughness and strength

Based on Figure 6, it is clear that EPR content of 16 phr gives balance properties with respect to impact strength (toughness) and tensile strength. However, when toughness and stiffness are considered, the optimum content is found to be around 18 phr as illustrate in Figure 7.

## 4. Conclusion

The study investigated the effect of EPR on flexural, tensile and impact properties of talc filled PP. The main objective was to determine the effectiveness of EPR as impact modifier for talc filled PP. The study shows that the additions of EPR in talc filled PP decreased the Young's modulus, tensile strength, flexural modulus and flexural strength. EPR is found to be an effective impact modifier for talc filled PP. The impact strength increased significantly with the incorporation of EPR. The enhancement of toughness of talc filled PP has important practical implication on its range of applications. From this study, it concluded that the optimum content of EPR in talc filled PP which posses balance mechanical properties is between 16 to 18 phr. Further study need to be conducted, i.e. using microscopy to determine the distribution of talc and EPR and to correlate the morphology with the properties of the composites.

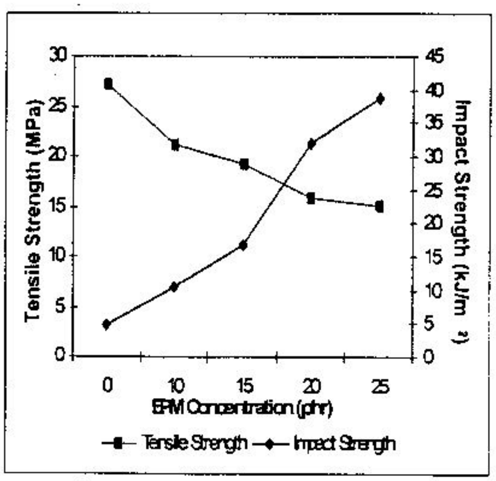


Figure 6. Balance of mechanical properties based on toughness and strength.

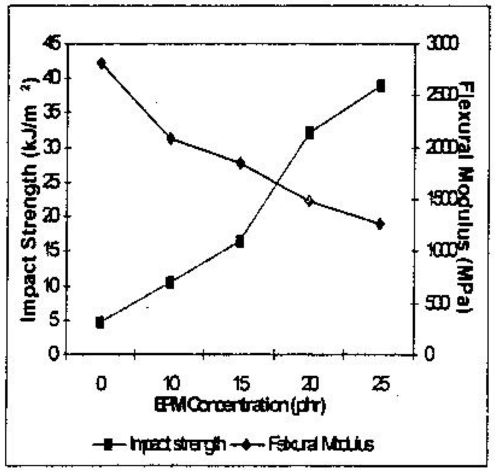


Figure 7. Balance of mechanical properties based on toughness and stiffness.

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