CHAPTER IV

RESULTS AND DISCUSSION

4.1 Preparation of composite

The PP/EPDM blends were prepared according to the procedure outline in 3.3. The X-ray fluorescence is used to characterize the elemental materials of commercial resins A and B compared with that of the composite. The elemental materials generally are from raw materials such as PP, EPDM, additives and so on. Therefore, the different materials and sources will give the different X-ray patterns. The X-ray fluorescence patterns (shown in Appendix II, Figure 1 to 3) reveal that the PP/EPDM blends compose of elemental materials such as Zn, Cu, Ni, Fe, Cr, Mn, Mg and Si similar to that of commercial resin A. However, the blend shows some difference with commercial resin B. It indicates that there are other materials in commercial resins A and B, or commercial resins A and B is from different material sources.

DSC curves illustrating melting behavior of the pure PP, EPDM, HDPE, commercial resins A, B and the prepared PP/EPDM blends are shown in Appendix II, Figure 4 to 9. The melting temperatures of commercial resins A, B and prepared PP/EPDM blends occur at about 163°C the same as pure PP. The melting temperature of commercial resin A at 125°C indicates the possible presence of HDPE. No melting peak was detected in the EPDM curve, which shows its amorphous state. In addition, the melting temperatures of the prepared PP/EPDM blends show similar peak with that of commercial resin B. These systems present immiscible blends in which the continuous phase is formed by the polymer that is present in higher quantity (23).

4.2 Mechanical properties of commercial resins

The purpose of this research is to improve mechanical properties of flexural strength as well as impact strength, melt flow index and hardness of PP/EPDM blends with some reinforced additives. At present, commercial resins A and B have been used for manufacturing the car bumpers according to their quality. Thus, their mechanical properties have been measured and used as the benchmarks to compare with those of the composites of this study. Commercial resin A illustrates lower MFI while its NI, FS and hardness are higher than commercial resin B which shown in Table 4.1.

Table 4.1 Mechanical properties of commercial resins

Resins	MFI (g/10 min)	NI ($kg.cm/cm^2$)	FS (kg/cm^2)	Hardness (Shore D)
A	9.3	8.7	271	48.3
B	18.9	5.7	226	43.9

4.3 Effect of EPDM level

The relative effectiveness of EPDM level on MFI, NI, FS and hardness of the composite was indicated in Figure 4.1. This can be observed that the addition of EPDM from 10 to 40 wt% resulted in the increase in NI to approximately 20 to 25%. On the other hand, MFI, FS and hardness decreased to approximately 25%, 16% and 5%, respectively. These observations are in agreement with the general acceptance that rubber provides a softer, tougher and more ductile polymer. The impact resistance is improved by the increase in rubber content.

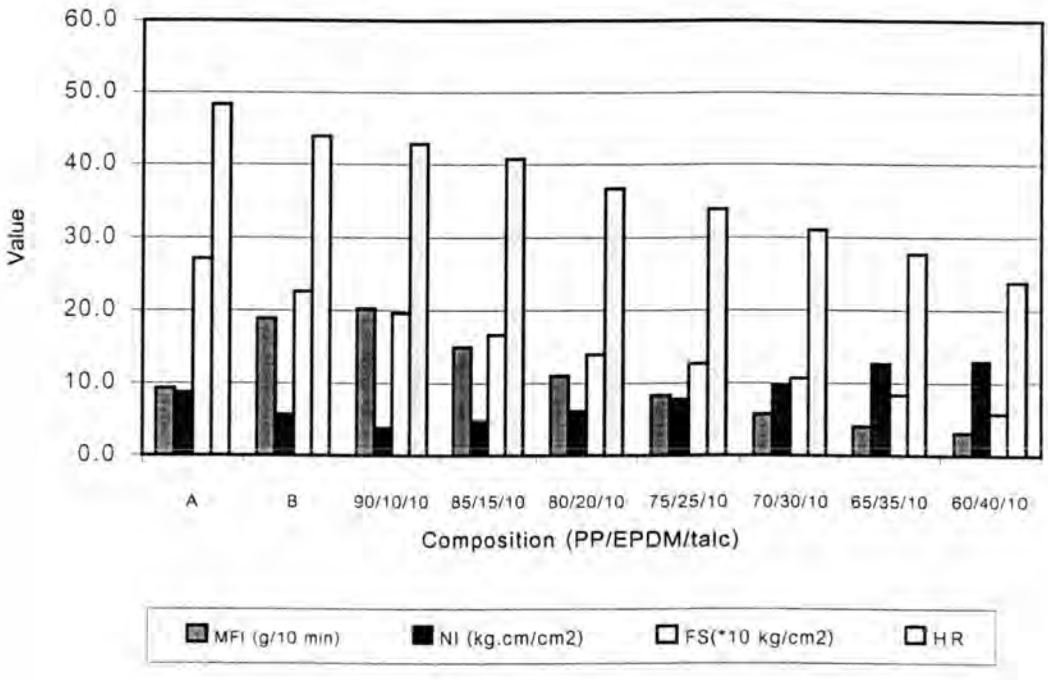

Figure 4.1 Effect of EPDM level on mechanical properties of PP/EPDM blends compared to commercial resins A and B.

From the result, PP/EPDM/talc at 80/20/10 gave higher MFI and NI than commercial resins A and B, respectively. Although, the blends showed much lower FS and hardness than commercial resins A and B, but it was expected to be improved by adding reinforced additives.

4.4 Effect of reinforced additives

Figure 4.2 shows the effect of various reinforced additives incorporated into PP/EPDM/talc at 80/20/10 on mechanical properties. It was obvious that clay had little effect on all properties while talc lowered MFI, but increased in FS and hardness on higher loading. On the other hand, carbon black decreased quite large magnitude of MFI while increased in NI, especially at 15 wt% loading. This is because reinforced additives generally serve to increase in FS, hardness as well as durability, which depend on structure, particle size and interaction between reinforced additives and PP matrix. Talc and clay used has average particle size of approximately 70 micrometre while carbon black has smaller particle size at 51 nanometre. In addition, the dispersed phase generally is 0.3-1.0 micrometre in average size. As a result, carbon black may disperse into both PP matrix and dispersed phase, which resulted in the increase in NI of the composite. Hironari and Hiroshi (12) reported this effect of reinforced additives on NI that when reinforced additive ($CaCO_3$) with relative large average particle size was dispersed only in the matrix, the NI of the composite had less than half of an unfilled polymer composition. On the other hand, when reinforced additive having a moderately small particle size (0.15-0.5 micrometre) was incorporated into the matrix, the NI of polymer increased to approximately 20 to 30 % of an unfilled polymer composition. But if it is incorporated into dispersed phase, the NI of the resulting polymer composition significantly improved.

Finally, it could be concluded that 15 wt% carbon black gave high NI while 15 wt% talc gave good MFI and FS. However, all the blends could not compete with commercial resins A and B especially on FS and MFI.

4.5 Effect of PP level

In order to improve MFI and FS, various amount of PP were mixed with 15 wt% talc and 15 wt% carbon black. The effect of PP on mechanical properties is shown in Figure 4.3. It is obvious that PP/EPDM/talc/carbon black at 90/10/15/15 illustrates higher MFI, FS and hardness than that at 85/15/15/15. Nevertheless, NI is still low. Addition of PP could increase in MFI, FS and hardness of the composite but decrease in NI of the composite. However, it still has lower FS than either commercial resin A or B.

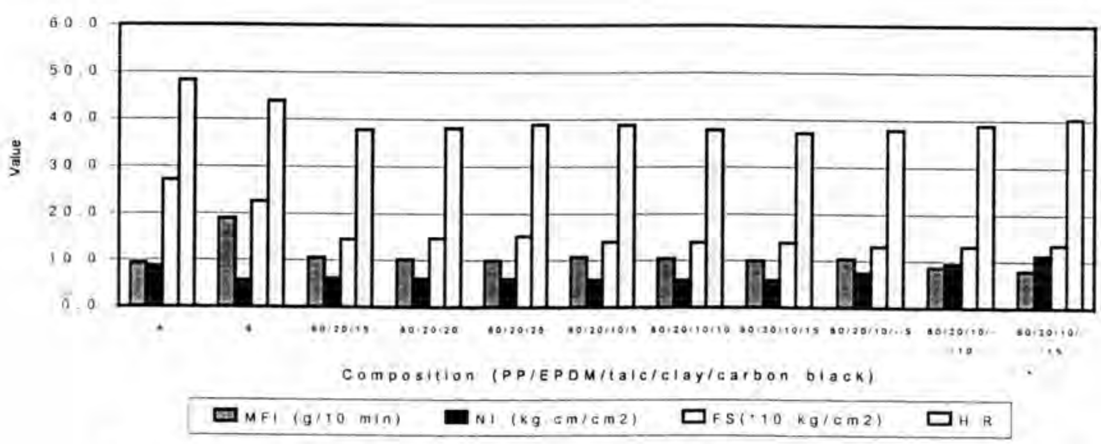

Figure 4.2 Effect of reinforced additives on mechanical properties of PP/EPDM blends.

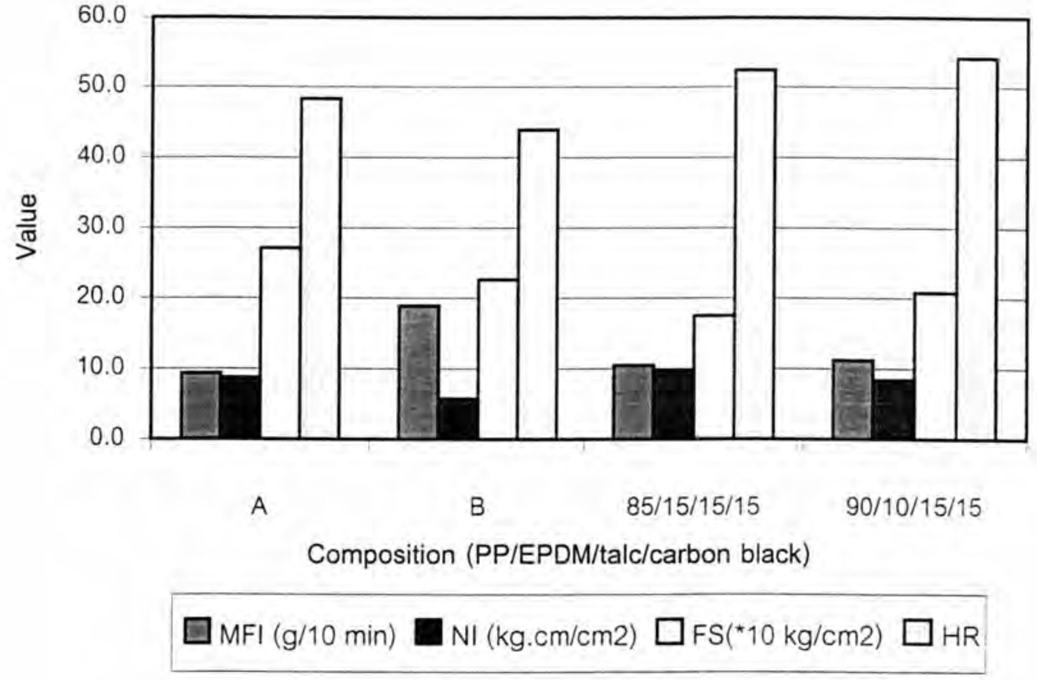

Figure 4.3 Effect of PP on mechanical properties of PP/EPDM blends.

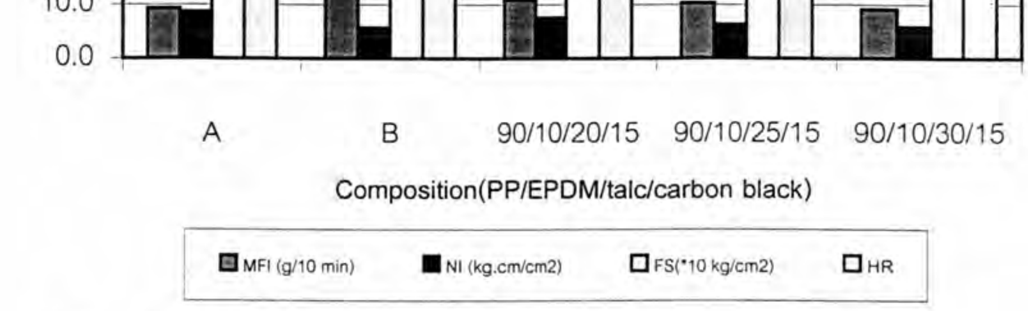

Figure 4.4 Effect of talc on mechanical properties of PP/EPDM blends.

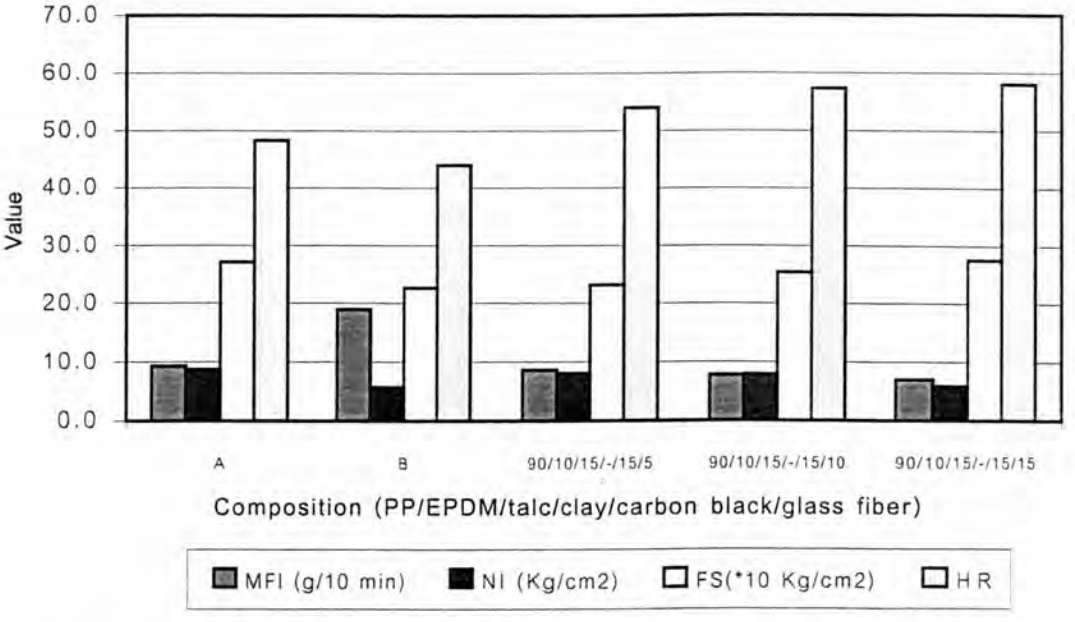

Figure 4.5 Effect of glass fiber on mechanical properties of PP/EPDM blends.

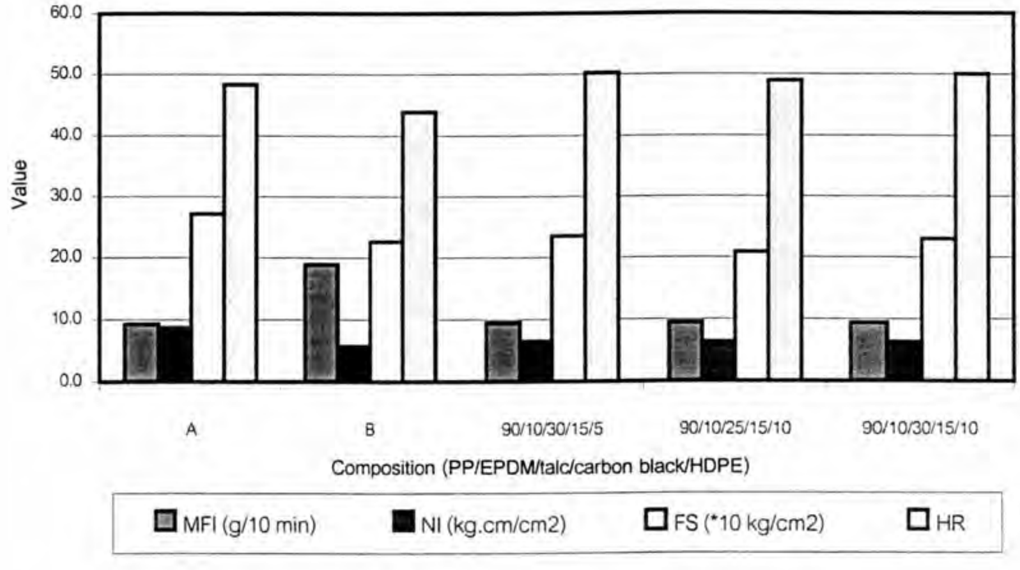

Figure 4.6 Effect of HDPE on mechanical properties of PP/EPDM blends.

4.6 Effect of talc loading

As shown in Figure 4.4, talc could increase in FS. In order to increase in FS of PP/EPDM/talc/carbon black at 90/10/15/15, higher talc loading were prepared. The effect of higher talc loading of 20, 25 and 30 wt% is shown in Figure 4.4. The result indicates that PP/EPDM/talc/carbon black at 90/10/30/15 gives 5.9 kg.cm/cm^2 on NI, 248 kg/cm^2, and 53.5 (shore D) on hardness, higher than commercial resin B which shows 5.7 kg.cm/cm^2 on NI, 226 kg/cm^2 and 43.9 (shore D) on hardness. Therefore, MFI is approached to that of commercial resin A while its NI and FS are still lower.

4.7 Effect of glass fiber loading

The glass fiber was expected to increase in FS of PP/EPDM/talc/carbon black at 90/10/15/15. The silane coupling agent was used to provide superior bonding between the glass fiber and resin in the composite. The effect of glass fiber is shown in Figure 4.5. It can be seen that increasing the amount of glass fiber, FS and hardness are increased while MFI and NI decreased. Although FS increase quite significantly with higher loading but its MFI is lower than either commercial resin A or B. As expected, the incorporation of glass fiber increases markedly the composite hardness. The density of the composite increases with fiber content due to the close packing of fiber. The effect of glass fiber on MFI can be explained that the distribution of fiber may not parallel with loading direction due to material flow during a mixing process.

4.8 Effect of HDPE loading

As shown in DSC curve of commercial resin, it indicates the melting temperatures of HDPE. So, it is expected to improve in mechanical properties especially MFI as well as FS and NI of PP/EPDM blends by incorporating HDPE into polymer blends. The effects of various amount of HDPE on mechanical properties of PP/EPDM blends are shown in Figure 4.6. It is obvious that the composite containing HDPE at 5 wt% increased in MFI and NI, but decreased in FS and hardness. This is because HDPE used in this study has high MFI (15 g/10 min) compared to that of the composite. In addition, HDPE usually disperses in PP matrix. Further increasing the amount of HDPE resulted in the decrease in all mechanical properties.

Finally, the best balanced composition in this work is PP/EPDM/talc/carbon black at 90/10/30/15, which gives higher NI and FS than commercial resin B while MFI is close to that of commercial resin A. In addition, hardness is higher than either those of commercial resin A or B.

4.9 The state of dispersion of the blends

It is a well-established fact that the state of dispersion in a heterogeneous polymer blend greatly influences its rheological behavior. SEM was used to investigate the state of dispersion of polymer blends in this work.

SEM micrographs of commercial resins A, B and the prepared PP/EPDM are shown in Appendix II (Figure 9 to 12). The micrographs reveal that EPDM and additives are dispersed in PP matrix. The micrographs also show that commercial resin A is distributed much better and more regular than the commercial resin B and the prepared composite. That indicates better adhesion between the two phases than commercial resin B and the prepared composite. In addition, the morphology of prepared looks similar to commercial resin B.

4.10 Economic consideration

From the results of this research, the best composition is PP/EPDM/talc/carbon black at 90/10/30/15, which its mechanical properties approach to those of commercial resins A and B. The cost of this composite is based on the cost of PP, EPDM, talc, carbon black and antioxidant. The costs of PP, EPDM, talc, carbon black and antioxidant in July, 98 are approximately 32, 85, 4.50, 115 and 500 bath/kg, respectively while commercial resins A and B is 175 and 150 baht/kg, respectively. Table 4.2 indicates the cost of prepared composite. It can be seen that the cost of prepared composite per kilogram is relatively low. Therefore, the price of the prepared composite will be attractive as an alternative to replace import commercial resins. However, it is noteworthy that this cost of composite does not include the cost of mixing and other management cost.

Table 4.2 Cost analysis of the prepared composite

PP / EPDM Composite	Materials Cost in July, 1998 (baht/kg)					Cost of Composites (baht/kg)
	PP	EPDM	Talc	Carbon black	Antioxidant	
90/10/30/15/0.2	19.83	5.86	0.93	11.88	0.7	39.20