THE EFFECT OF TALC MINERAL FILLERS ON THE PHYSICAL PROPERTIES OF ETHYLENE-OCTENE/POLYPROPYLENE BLENDS

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Abstract

Mineral fillers have been used as effective reinforcing agents in polypropylene TPO formulations for decades. High aspect ratio talcs with their platy structures have been effectively used to increase stiffness (flexural modulus) and provide improved dimensional stability in TPOs. This paper examines the physical properties of talc filled polypropylene:ethylene octene blends as a function of talc size and concentration.

Introduction

Polypropylene (PP) and rubber reinforced polypropylene resin systems are extensively used in molded automotive exterior and interior parts, appliance housings, films and textile fibers. In recent years, there have been an increasing number of studies examining the advantages of metallocene α-olefins, such as ethylene/1-octene (EO), at improving the toughness of polypropylene compared to more conventional EP and EPDM elastomers.[1,2] The advantage of EO compared to EP is that EO has a lower glass transition temperature (remains rubbery at lower temperatures) and provides greater tensile properties at equal loadings.[3,4]

While elastomeric copolymers can significantly improve the impact resistance of polypropylene, they tend to greatly decrease the stiffness of the polypropylene homopolymer.[5] High aspect ratio talcs can be used to regain and, at high enough loading levels, surpass the stiffness of the original PP resin. Finely ground talcs can actually improve both the stiffness of the TPO and improve the compound's Izod and the falling weight impact strengths when used in conjunction with the EO plastomer.

This paper will examine the balance of stiffness and toughness achievable by varying the concentration of the EO elastomer. It will also investigate the effect of the median and topsize of the talcs as well as their concentration.

Experimental

A 20 MI polypropylene injection molding grade homopolymer (Huntsman PP P4C5Z-027) was used throughout these experiments. The ethylene/octene plastomer employed in these studies was Affinity® EG 8200G manufactured by the Dow Chemical Company. Three talcs were examined in this study which will be referred to as Talc 1, Talc 2 and Talc 3 (Talc 1 being the finest, Talc 3 being the coarsest). All 3 talcs were supplied by Specialty Minerals Inc. (FLEXTALC® talc series).

The physical characteristics of the talcs are provided in Table 1. Particle size distributions were determined on a Micromeritics Sedigraph 5100 instrument. The 2 finer talcs were received in densified form to improve control of the feed rate into the extruder.

All PP/EO/Talc blends were compounded on a Leistritz 34 mm counter rotating twin screw extruder at a die temperature of 200 ^{o}C. After compounding, all composite materials were molded into test specimens on an 84-ton Arburg injection molding machine at a melt temperature of 200 ^{o}C. The test specimens were conditioned in a CTH environment and tested in accordance with ASTM procedures.

The PP/EO/Talc blends were evaluated in two different studies:

Study 1: Four masterbatches of EO/PP were pre-blended in a laboratory Henschel mixer at 15%, 20%, 25% and 30% (weight %) EO. Talc 1 was compounded at 0-30% (weight %) into the masterbatches using the Leistritz extruder at the conditions specified above. This effectively keeps the ratio of PP/EO constant. The overall concentration of EO and PP will decrease proportionately as talc is introduced into the resin system.

Study 2: The PP, EO and Talcs 1, 2 and 3 were introduced separately into the extruder. The total concentration of EO in the composite was kept constant at 25 wt%. The PP resin concentration decreased proportionally in the system as the concentration of talc increased.

Results and Discussion

Study 1: This study examined the effect of EO and the concentration of Talc 1 on the physical properties of a PP homopolymer. The physical characteristics of Talc 1 are presented in Table 1. In this study, the ratio of EO:PP was kept constant at 0, 15, 20, 25 and 30 wt. % EO. As the talc filler was compounded into the PP and PP:EO blends, the effective concentration of EO in the total compound decreased proportionally with increasing talc concentration. Figure 1 shows the room temperature Izod Impact strengths for the PP:EO and the PP:Talc 1 blend. Figure 1 also compares the Izod Impact of the EO:PP:Talc 1 blend at a 30 wt. % EO/PP ratio. Talc 1 showed no increase in Notched Izod Impact over the barefoot PP resin as a function of increasing filler level. There is a sharp increase in Izod Impact above a 20 wt. % EO concentration in the EO:PP blends. The EO had little effect on Izod impact below 20 wt. %. This trend is in agreement with the work published by Huneault, et al.[1]

The addition of Talc 1 effectively decreases the EO concentration in the compound. The greater the talc concentration, the lower the total EO concentration in the final compound. This is represented by the black fitted line in Figure 1 which has a similar shape to the EO:PP unfilled blend. The concentration of EO in the total system was found to dominate the Izod Impact values.

Mechanical properties of the PP:EO, PP:Talc 1 and PP:EO:Talc 1 blends are presented in Table 2. For blends containing EO and PP the ratio was kept constant at 30 wt.% EO/ 70 wt. % PP. Addition of talc increases the stiffness of the PP and PP:EO blends in all cases. The greater the concentration of Talc 1, the greater the final stiffness of the composite. The addition of EO to the formulation decreases the stiffness of the PP and PP:Talc blends. This is demonstrated graphically in Figure 2.

EO addition to the PP resin at the concentration examined in this study greatly increases the room temperature Dynatup falling weight energy (Table 2). While Talc 1 alone does not increase the Dynatup energy, its combination with the EO provides a slight improvement over the EO alone. This is presumably a result of the talc increasing the stiffness of the EO:PP while maintaining 100% ductile failure benefit of the EO plastomer. As stated above, the Izod impact appears to be a function of the total EO content in the composite and decreases with increasing talc concentration due to an EO dilution effect with increasing talc loading levels.

Study 2: This study examined the stiffness/ Izod impact balance as a function of the size and concentration of talc mineral filler in a PP:EO composite. The concentration of EO was kept constant at 25 wt. % throughout this study. The concentration of the PP resin decreased as a function of increasing talc addition levels. The sizes of the 3 talcs used in this study are presented in Table 1.

The addition of talc to the composite was found to greatly increase the stiffness by approximately the same magnitude, regardless of the size of the talc (see Figure 3). This is true within the confines of the talcs examined in this study. Talcs outside the median and topsize range of those used in this study may provide different results. Increasing the talc loading level from 10 wt. % to 20 wt. % provided modest increases in the stiffness of the composite.

Figure 4 shows the Notched Izod impacts as a function of talc size and talc addition level. The finest Talc (Talc 1) was found to increase the Izod impact over the EO alone. Higher levels of the intermediate size talc (Talc 2) were required to improve the impact over the EO:PP composite. The coarsest talc (Talc 3) examined in this study reduced the Izod impact over the EO:PP blend at all levels.

Conclusions

These studies examined the effect of the addition of finely ground talcs on the physical properties of polypropylene/ethylene octene TPO blends. The main points from these studies are:

Study 1:

Notched Izod impact strength was dependent upon the concentration of EO in the total formulation. Little improvement in Notched Izod was observed compared to the barefoot resin below an EO concentration, in the entire formulation, of 20 wt. %.

The PP filled with Talc 1 provides a significant increase in polymer stiffness compared to the barefoot PP resin. This increase in stiffness tracks with the talc concentration, as expected. The higher the talc loading level, the greater the stiffness. EO increases Izod impact (at > 20 wt. %) but has a negative effect on the polymer stiffness. At a 20% talc filler level, the original stiffness of the PP barefoot resin is re-achieved in the presence of 30 wt.% EO/PP ratio. Additional increases in stiffness can be gained by increasing the talc concentration.

Study 2:

The addition of talcs greatly increased the flexural modulus at all levels examined in this study (10-20 wt. %) compared to the 25% EO:PP unfilled system. All of the fine talcs examined in this study increased the flexural modulus by approximately the same magnitude at each loading level. The magnitude of the increase in flexural modulus was found to increase with increasing talc loading level.

Izod impact increases with the incorporation of the finest talc (Talc 1) examined in this study at all three addition levels. The coarsest talc (Talc 3) examined in this study decreased the Izod impact compared to the 25% EO:PP blend at all levels. The talc of intermediate size (Talc 2) had little to a modest increase in Izod compared to the EO:PP unfilled blend.

The best balance of Izod Impact and Flexural Modulus was achieved at EO concentrations > 20 wt. % and with the finest talc examined in this study (Talc 1) at levels > 10 wt. %.

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References

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Keywords
Polypropylene, TPO, Talc, Ethylene Octene, Impact, Flexural Modulus.

Table 1. Physical Properties of the Talc Minerals

Talc No.	Median Particle Size (µm)	Topsize (µm)	Densified
1	1.0	6	Yes
2	1.9	8	Yes
3	2.2	12	No

Figure 1. Room Temperature Izod Impact of the TPO Formulation as a Function of EO and Talc Concentration

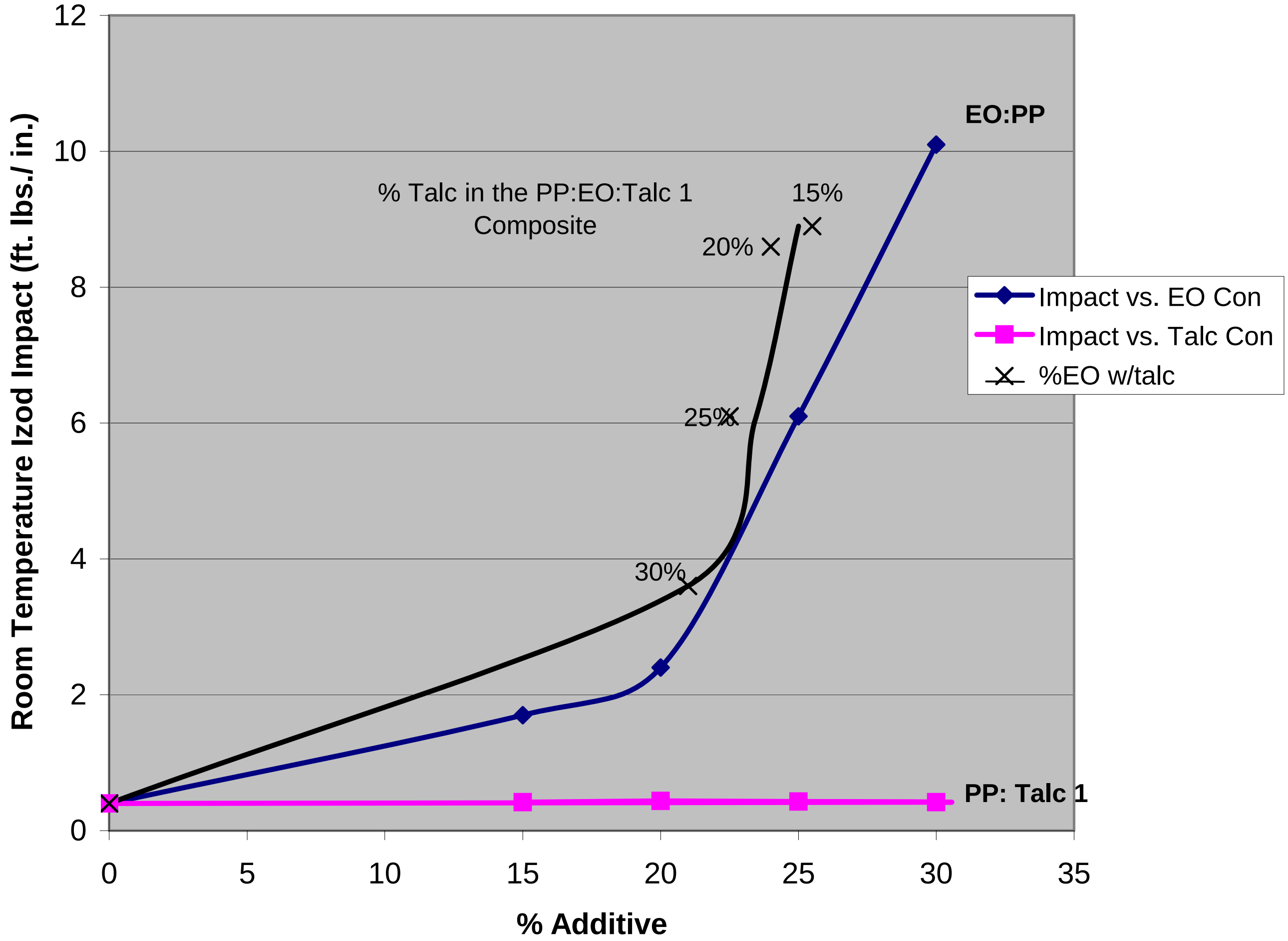
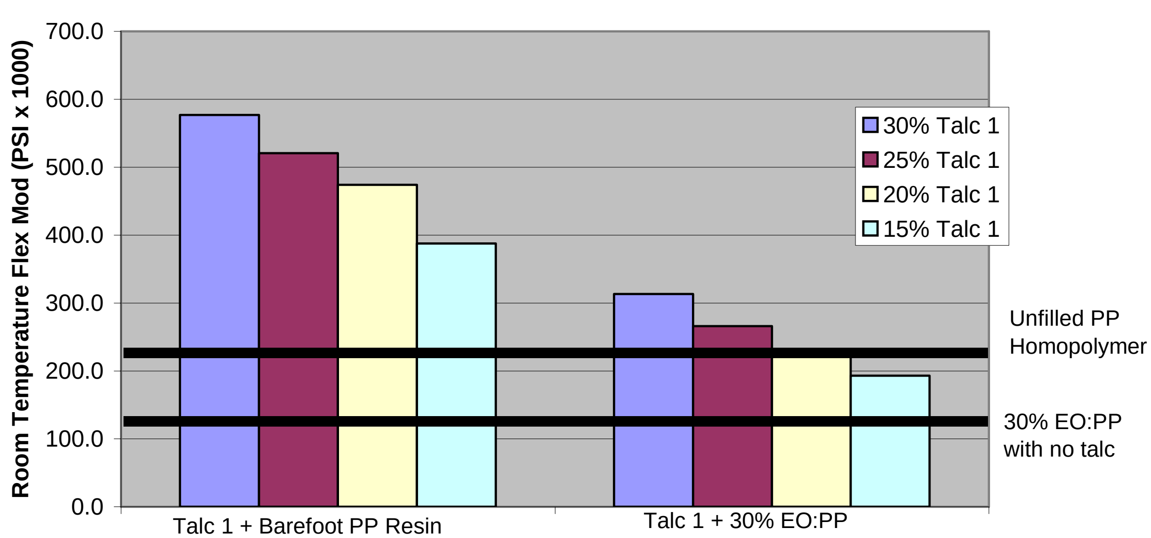


Table 2. Mechanical Testing Results of PP/EO/Talc 1 Blends.

				Dynatup Falling Weight Impact		
Talc 1 **(%)**	*PP/EO* **(%)**	**Conc. EO in Filled System (%)**	Flex Mod. **(PSI)**	**Energy @23°C (ft. lbs.)**	Ductile Failure **(%)**	Notched Izod Impact @23°C **(ft. lbs./in)**
0	100/0	0	226,000	1.1	0	0.40
15	100/0	0	387,500	0.58	0	0.42
20	100/0	0	473,900	0.83	0	0.44
25	100/0	0	520,800	0.72	0	0.43
30	100/0	0	577,000	0.67	0	0.42
0	70/30	30	126,100	12.6	100	10.1
15	70/30	25.5	193,000	13.7	100	8.9
20	70/30	24.0	223,900	13.4	100	8.6
25	70/30	22.5	266,200	13.4	100	6.1
30	70/30	21.0	313,200	13.6	100	3.6

Figure 2. Flexural Modulus as a Function of Talc 1 and EO Concentration



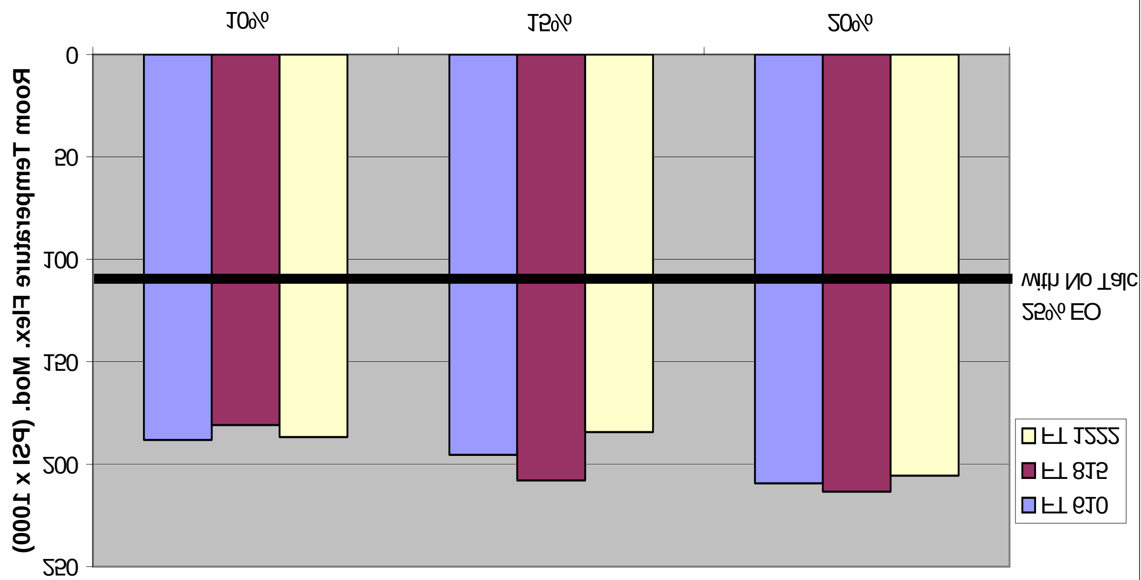


Figure 3. Flexural Modulus as a function of Talc Size and Concentration at a Constant 25% by Weight EO Concentration in the TPO Compound.

Figure 4. Notched Izod vs. Talc Size and Concentration at a Constant 25% by Weight EO Concentration in the TPO Compound.