Investigation on Mechanical Properties of Polypropylene-Polyamide6-Glass Fiber Composites

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ABSTRACT

The mechanical properties of the polypropylene-glass fiber compounds were evaluated compared to the polypropylene-polyamide6-glass fiber composites. The comparison of these four systems has been made over the 0-15 wt% PA6 content range. Also two different types of compatibilizers were tested on sample containing 10% wt polyamide6. The results indicate that the increasing the PA6 content leads to increases the tensile strength and Izod impact strength. The optimal amount of mechanical properties such as tensile strength, Elongation at breakage, and impact resistance were obtained in a composites containing 10% wt of polyamide6. PP-g-MH and Ethylene -Ethyl Acrylate-Maleic Anhydride Terpolymer as a compatibilizer, was evaluated. The results indicate that only PP-g-MH plays a compatibilizer role.

Keywords: *polypropylene, polyamide6, compatibilizer.*

1. INTRODUCTION

Polypropylene (PP) and Polyamide (PA) are general-purpose thermoplastic materials. PP is mostly used for automobile parts and daily necessities, because of its low cost, high processability, high water/chemical resistance, and so on. However, as for shortcoming of PP, it has relatively low modulus and poor heat resistance. Although PA exhibits high toughness and high heat resistance, it has not only a high affinity with water but also poor acid resistance. Thus, PP/PA blend materials are expected to improve their mechanical properties. Unfortunately, these polymers are incompatible because of their different polarity and crystalline morphologies. Therefore, compatibilizing agent has to be used to reduce the interfacial tension and to improve the adhesion between two constituents [1-4].

2. EXPERIMENTAL

Homopolypropylene used in this study was a commercial (MFI: 4gr/10min) and polyamide6 (Modulus: 2750 Mpa) were used. In order to improve the properties of the compound a combination of glass fiber, Masterbatch, and PP-g-MA, as Addetive1, and combination of glass fiber, Masterbatch, and Ethylene -Ethyl Acrylate-Maleic Anhydride Terpolymer, as Addetive2 was used. Addetive1 and Addetive2 are similar, and their only difference is in the type of compatibilizer. In this study, five different combinations of the composites were studied .The composition of samples tested are given in Table 1.

Table1. The composition of samples tested

Materials	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
Homopolypropylene	100	--	54	49	44	39	44
PA6	--	100	--	5	10	5	10
Additive Package 1	--	--	46	46	46	46	--
Additive Package 2	--	--	--	--	--	--	46

Polypropylene-polyamide6-glass fiber composites were prepared in a co-rotating twin-screw extruder (CYKF-CY-58HT) at temperature ranging from 210 to 240°C. Tensile and Impact properties was carried out according to ASTM D638 and ASTM D256.The test Resistance of the maximum torque and Endurance torque carried out according to customer's standards.

3. Results and Discussion

The mechanical properties of the polypropylene-glass fiber compounds and polypropylene-polyamide6-glass fiber composites are shown in Table 2.

Table2. The mechanical properties of samples tested

Sample	Tensile Strength at Break MPa	Elongation at Break %	Izod Impact Strength KJ/M^2
Sample 1	26.4	20.7	8.6
Sample 2	59	9.7	14.6
Sample 3	58.5	5.4	11.7
Sample 4	72.8	6.2	22.8
Sample 5	81	8.4	25.5
Sample 6	72.3	6.3	23.1

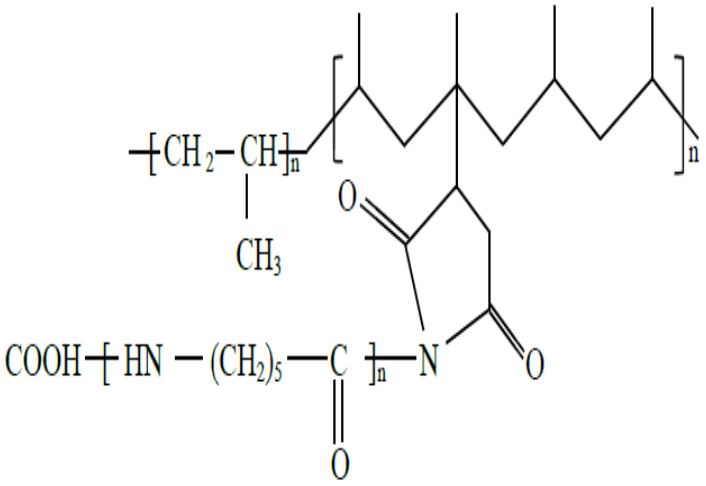
In comparison of the results of polypropylene-glass fiber compounds and pure polypropylene samples mechanical Analysis showed that adding the glass fiber enriched an increase Tensile Strength at Break from 26.4 MPa to 58.5 MPa. As well as impact strength increased from 8.6 KJ / M^2 to 11.7 KJ / M^2**.** The results indicate that use of compatibilizer such as PP-g-MA reduce the interfacial tension and to improve the adhesion between constituents. On the other hand the results showed that the addition of 5%wt polyamide 6 to the polypropylene-glass fiber compounds resulted in an increase of the Tensile strength at Break from 58.5 MPa to 72.8 MPa. Also, the Izod impact strength increased from 11.7 KJ/M^2 to 22.8 KJ/. Therefore, the results showed a positive deviation. Increasing the content of polyamide6 from 5 to 10% has led to increase the Tensile strength at Break from 72.8 MPa to 81 Mpa and impact resistance has increased from 22.8 KJ / M^2 to 25.5 KJ / M^2.Increasing the content of polyamide6 from 10 to 15% has led to a decline in mechanical properties. In fact poor dispersion of polyamide6 particles in matrix resulted in decreasing mechanical properties. Therefore the optimal amount of mechanical properties such as tensile strength, Elongation at breakage, and impact resistance were obtained in a composites containing 10% wt of polyamide6.
The mechanical properties of the polypropylene-polyamide 6-glass fiber composite containing 10% polyamide 6 were evaluated using two types of compatibilizer, PP-g-MH and Ethylene -Ethyl Acrylate-Maleic Anhydride Terpolymer as a compatibilizer. Results are listed in the Table 3. The results indicate that use of Ethylene -Ethyl Acrylate-Maleic Anhydride Terpolymer as a compatibilizer resulted in a decrease of mechanical properties.

Table3. The mechanical properties of composite with two type of compatibilizer

Sample	Tensile Strength at Break MPa	Elongation at Break %	Izod Impact Strength KJ/M^2
Sample 5	81	8.4	25.5
Sample 7	32	4.7	12.2

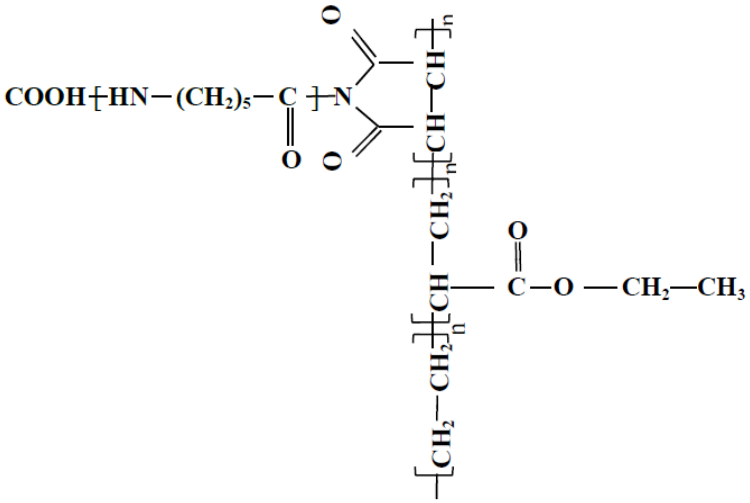
The reaction between PA6 and PP-g-MA occurs between C-O-C of MA and -NH2- of PA6 to form C-N-C bond. The reaction occurred between PA6/PP blend and PP-g-MA has been illustrated in Figure 1.On the other hand, the presence of polypropylene in the structure of compatibilizer has led to an appropriate interaction with the matrix. The presence of above reaction leads to reduce the interfacial tension, improve the adhesion between constituents and good dispersion of PA6 particles in the matrix.

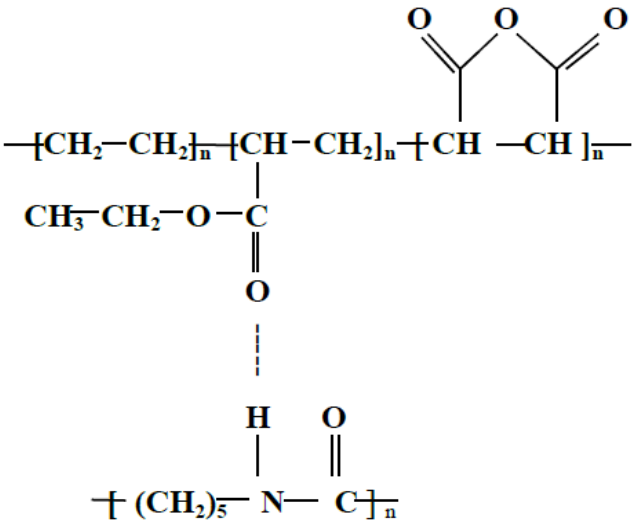
Figure1. Reaction between PA6, PP and PP-g-MA



Use of Ethylene -Ethyl Acrylate-Maleic Anhydride Terpolymer as a compatibilizer resulted in reaction occurs between C-O-C of MA and -NH2- of PA6 to form C-N-C bond. Also some N-H groups from hydrogen bonds reaction with C=O groups of Ethylene -Ethyl Acrylate-Maleic Anhydride Terpolymer. The reaction occurred between PA6/E-EA-MA has been illustrated in Figure 2.

Figure2. Reaction between PA6, and E-EA-M





It is probable that E-EA-MA particles are dispersed through PA6 phase to form layers in order to isolate PA6 particles from the PP matrix therefore the domain size of dispersing drastically increases and the dispersing phase made up of PA6 and E-EA-MA is large. This is indicative of inappropriate dispersion.
The results of the tests performed on the injected parts of customer are shown in Table 4.

Table4. The results of the tests performed on the injected parts of customer

Test	Sample 3	Sample 5
Resistance of the maximum torque	Failure and cracks in the Torque 138.9N.M were observed	There are no cracks and failures up to 200 N.M Torques
Endurance torque	Failure and cracks in the Torque 136N.M were observed	There are no cracks and failures up to 150 N.M Torques

The results show an improvement in Resistance of the maximum torque and Endurance torque. The improvement of the Above results can be attributed to the increase of torsional modulus.

CONCLUSIONS

In this research mechanical properties of the polypropylene-glass fiber compounds were evaluated compared to the polypropylene-polyamide6-glass fiber composites. Also two different types of compatibilizers were tested on sample containing 10% wt polyamide6.

- The results indicate that the optimum mechanical properties are achieved by increasing the PA6 content by 10%wt.
- Only the polypropylene grafted maleic anhydride has played the role of compatibilizer.

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