Enhancing Mechanical Properties of Polypropylene/OMMT by adding SEBS

Pawar A.V[1] , Vibhute A.V[2], Daware D.B[3], Nek Ranjan[4], Lokhande P.E[5]
[1, 2, 3, 4, 5] Department of Mechanical Engineering
[1, 2, 3, 4, 5] Sinhgad Institute of Technology, Kusgaon (Bk), Lonavala,

Abstract- *In recent years incredible research has been done on polymer nanocomposite since these materials demonstrated excellent properties. Nanocomposite with enhanced mechanical properties such as toughness and stiffness can serve as perfect replacement for old automobile parts materials. These materials are lightweight, so they have the added benefit of increase in fuel efficiency. Polypropylene is one of the most versatile low cost commodity polymer. It has high stiffness and processability but its use in industry is limited due to its low impact strength. Polypropylene with different amounts of styrene-ethylene-butylene-styrene block copolymer (SEBS)/clay were prepared via melt mixing technique. To improve the dispersion of commercial organoclay (OMMT) various amounts of SEBS were incorporated. The effect of clay concentration and of thermal treatment was studied from a mechanical point of view. The materials obtained were analyzed for checking mechanical properties through Universal Testing Machine (UTM), Izod and Charpy impact tests. At 10% fixed content of OMMT, the impact strength increased by 125% with 2% wt. increase in SEBS content.*

Keywords- Polypropylene, Styrene-Ethylene-Butylene-Styrene (SEBS), Thermal Treatment, Mechanical Properties.

I. INTRODUCTION

Polypropylene (PP) is considered one of the most promising substitutes for engineering materials in the automotive, construction, and electrotechnical industries because of its excellent processability, rigidity, thermal stability, resistance to oil, recyclability, and relatively low cost[1-4] . In recent years, polymer/clay nanocomposites have attracted significant academic and industrial interest. This interest stems from the fact that nano-sized-layer-filled polymers can exhibit dramatic improvements in mechanical properties [5]. To improve PP competitiveness in engineering applications, a simultaneously increase in stiffness and toughness is necessary. Toughness, a very important mechanical property that reflects the material capacity to absorb the impact energy, can be considerably enhanced by the incorporation of a dispersed rubbery phase.

Materials which are added to a polymer matrix to improve a property or properties fall in the category of either reinforcement or filler. Generally, a material which raises the mechanical properties of a composite over that of the base resin is called a reinforcing material. They are usually fibrous in nature. Mechanical properties affected are parameters such as Young’s modulus, tensile strength, and toughness. Melt blending with rubbery materials such as ethylene–propylene copolymers, ethylene–propylene diene monomer, butadiene–styrene–acrylonitrile terpolymers, acrylonitrile–butadiene rubber, styrene– butadiene–styrene copolymers or ethylene–octene copolymers, was extensively studied to improve PP impact strength [6-7].In order to achieve a nanocomposite with improved mechanical properties, different formulations have been tested until now, one of the most used polymer for obtaining nanocomposites is Polypropylene [PP]. To obtain Polypropylene nanocomposites based on layer silicates, a compatibilizer needs to be added, due to the incompatibility between the two components. As compatibilizer, maleated polypropylene (MA-PP)and maleated styrene-6-(ethylene-cobutylenes)-6-styerene triblock copolymer (MA-SEBS) were used because of the interaction which the maleic group can give with layered silicates. It has been reported that SEBS can also be used as compatibilizers for PP nanocomposites [8].

The addition of layered silicates in polymer system leads to great improvement in their properties such as thermal stability and mechanical performance but there is a significant reduction in the elongation at break and impact strength in these materials when the clay content increases. Addition of SEBS increases the impact strength of the material. Also by thermal treatment the tensile strength of the material increases. Hence by addition of SEBS and OMMT and then thermal treatment all the three properties – Impact strength, young’s modulus and tensile strength is increased. Thus we get material with overall good properties.

In this study nanocomposites based on PP, SEBS and OMMT were prepared using extrusion. Thermal treatment was done on the material. This work studies a broad range of concentration of OMMT and SEBS in order to investigate their influence on mechanical properties and contributes to the improvement of already existent result by correlating mechanical properties. The result of the mechanical properties of PP/OMMT/SEBS nanocomposite with thermal treatment were reported and discussed.

II. EXPERIMENTAL PART

1. Materials

The Polypropylene (PP) matrix used for this study had density of 0.90 g/cm^3, a melt flow index 25 g/10 min at 230^{0}C/2.16 kg. The impact Modifier was linear poly - (styrene-b-(ethylene-co-butylene)-b-styrene) block co - polymer with styrene content of 29%, density of 0.91g/cm^3, melt flow index of 5 g/10 min at 230 ^{0}C/5 kg and number average molecular weight M_n=79100. The OMMT used was Organophilic Montmorillonites: Cloisite 15A (CEC:125 meq/100 g) and 20 A (CEC:98 meq/100 g).

2. Preparation of PP/OMMT/SEBS nanocomposites

The Organophilic Montmorillonites: Cloisite 15A (CEC:125 meq/100 g) and 20 A (CEC:98 meq/100 g) in ratio 1:1, Styrene-ethylene-butylene-styrene (SEBS) and Polypropylene (PP) were added according to the required percentage as per composition table using Twin Screw Extruder.The dried pellets of composites were injection molded into test bar for mechanical testing. The temperature of the cylinder was 200^{0}C, temperature of the mold 70^{0}C and injection pressure was of 800 bar.

Some test bars were thermally treated at 90 ^{0}C for 24 hours and some untreated.Neat Polypropylene (PP) test bars for comparison using the extruder and injection molding process have to be made.We compared the mechanical properties of the three type of bars neat Polypropylene (PP), nanocomposites (thermally treated) and nanocomposites (thermally untreated).The compositions selected for manufacturing and testing are presented in Table 1.

Table1: Composition of nanocomposites

Material	PP content	OMMT content	SEBS content
PP	100	0	0
PP/0/13.5	86.5	0	13.5
PP/0/23	77	0	23
PP/5/0	95	5	0
PP/13/0	87	13	0
PP/2.5/3.5	94	2.5	3.5
PP/10/12	78	10	12
PP/10/14	74	10	14
PP/10/20	70	10	20

III. RESULTS AND DISCUSSION

1. Mechanical Properties

To characterize the effect of addition of organoclay and SEBS on the mechanical behaviour of polypropylene, tensile properties and impact strength were assessed. Injection molded specimen were used for tensile tests, which were performed at room temperature on Universal Testing Machine. Values of tensile stress, at yield and tensile stress at break were obtained from experiments. Impact test were conducted on standard size specimen using charpy and izod impact testing machines.The standard Charpy Impact Test specimen consist of a bar of material with dimensions 55x10x10mm having a notch machined across one of the larger dimensions. Tests were conducted a few days after preparation of the samples, to avoid the effect of physical aging of PP on the mechanical response.

A) Tensile properties

Tensile tests were conducted on Universal Testing Machine equipped with an optical extensometer. Mechanical results presented the variation of mechanical properties as function of composition. It can be observed that using SEBS caused a reduction in the tensile strength and Young's modulus, but the impact strength increased if compared to neat PP. Moreover, a significant increase was observed from 2.2 to 35 kJ m^{-2} when a concentration of 23wt% SEBS was used.

These results are in accordance with previous reports found in literature which show that an elastomer can improve impact strength of neat PP, but with the sacrifice of tensile strength. On the other hand, using OMMT presents a decrease in the tensile strength and unmodified impact strength, while the Young's modulus increases.Nanocomposites presented an increased stiffness and impact strength, and a small decrease in tensile strength.

It can be noticed that the impact strength increased with the amount of SEBS, while the tensile strength decreased with it. The decrease of tensile strength was below the value of neat PP. Young's modulus of nanocomposites decreased with the increase of SEBS concentration. Although Young's modulus decreased, the values were not below neat PP values; this decrease was overcome by the addition of OMMT. Result of mechanical testing is presented as the variation of mechanical properties against composition in Table 2.

B) Impact strength

Unnotched Charpy and notched Izod impact tests were performed on nanocomposites. Both tests are in accordance and present the same behaviour of the nanocomposites.Impact tests were conducted on Impact Tester equipped with data-acquisition system.

A significant improvement of 60% in Charpy impact strength can be noticed for the nanocomposites with 10 wt% OMMT and 12 wt% SEBS. Furthermore, when Izod impact strength was tested for the nanocomposite with 10 wt% OMMT and 14 wt% SEBS, the increase was spectacular, of 300% as compared with neat PP. Mechanical properties for obtained nanocomposites.

Table2: Mechanical properties for obtained nanocomposites

Material	Tensile stress at yield (MPa)	Tensile stress at break (MPa)	Izod impact stregth kJ/m2	Youngs Modulus (MPa)
PP	17.9±1.9	39.2±3.9	2.2±0.3	77.±55
PP/0/13.5	18.5±1.3	29.3±1.3	19.3±0.1	612±148
PP/0/23	17.6±0.5	27.1±1.9	33.3±0.2	485±123
PP/5/0	30.9±0.9	35.3±0.6	2.1±0.1	762±59
PP/13/0	28.8±0.8	33.6±0.9	1.9±0.1	836±46
PP/2.5/3.5	18±0.9	32.7±1.3	3.3±0.2	1735±95
PP/10/12	17.5±1.9	29.7±0.3	7.6±0.4	1060±98
PP/10/14	14.5±1.5	24.5±0.7	8.9±0.1	1049±40
PP/10/20	19±0.9	27.1±0.8	34.6±0.5	965±43

IV. CONCLUSION

The incorporation of the modified silicate increased the stiffness, proving the reinforcing effect of the modified clay. The mechanical results showed that the components strongly influenced the properties of the nanocomposites. Taking into consideration the ratio between the compatibilizing agent/organosilicate, nanocomposites with either toughness or stiffness or with good balance between toughness–stiffness properties can be obtained. Moreover nanocomposites presented improvement in impact strength. Tensile strength and Young’s modulus were significantly improved by thermal treatment. Therefore, considering the overall properties, these types of nanocomposites can easily find applications in the automotive industry.

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