Blending of Recycled Polypropylene and High Impact Polystyrene

V. Ganesh Ram

Department of Mechanical Engineering, Bharath University, Chennai, Tamil nadu, India

Abstract: Polypropylene (PP) and High Impact Polystyrene (HIPS) were obtained from E-waste by mechanical recycling. These thermoplastics are most found in E-Waste. In the present work, recycled material obtained from E-Waste is blended for upgrading the material properties. Recycled PP and recycled HIPS are most found material from E-Waste is melt mixed at different weight ratio and their mechanical properties were evaluated. Recycled PP and recycled HIPS are typically incompatible and form an unstable morphology when blended. Thus, organoclay (C20A) is used as compatibilizer for compatibilization of immiscible recycled PP/HIPS blends and properties obtained are compared with properties of material obtained by mixing with conventional compatibilizer SEBS. C20A and SEBS is melt mixed for improving interfacial adhesion as well as to reduce the domain size of dispersed phase in incompatible polymer blends.

Key words: PP · HIPS · TS · SEBS · C20A

INTRODUCTION

Recycled blends of PP/HIPS at 70/30, 50/50, 30/70 wt ratio were prepared using batch mixer (Torque Rheocord-9000, M/s Haake, Germany) with a screw speed of 50 rpm. Temperature was maintained at 170, 180 and 190°C in zone 1, 2 and 3 respectively for duration of 5 mins. Prior to mixing, PP and HIPS were predried at 60°C for 5 Hrs. Recycled PP and recycled HIPS where mixed simultaneously during blending. Specimens were prepared using compression press maintained at a temperature of 200°C, pressure of 50 kg/cm3 and cycle time of 10min.

Preparation of Recycled PP/HIPS Blend and its Nanocomposite and Specimen Preparation: The blend composition was optimized at 30/70 ratio of HIPS/PP and was maintained for preparation of polymer blend nanocomposites and compatibilized blend. Compatibilization of PP and HIPS using 3 and 5wt% of C20A was done simultaneously during melt blending. compatibilization using 5 and 7 wt% SEBS was carried out by melt mixing of Polystyrene and SEBS first then followed by adding PP. Specimens were prepared using compression press at 200°C, pressure 50 kg/cm3 and cycle time of 10min.

Mechanical Properties of Recycled PP/HIPS Blends: It is evident that recycled PP shows a tensile strength (TS) of 23.45 MPa with tensile modulus (TM) of 955.23 MPa and impact strength (IS) of 35.75 J/m respectively. Incorporation of HIPS to the tune of 30 to 70 wt%, results in significant reduction in mechanical properties in the blends. This reveals immiscibility between the two components resulting in the formation of two well differentiated phases indicating poor adhesion at the interface. Hence application of a load causes deterioration in mechanical properties of the material, predominantly due to stress concentration effect of the impurity. The effect of incorporation of compatibilizer, SEBS on the mechanical properties of PP/HIPS blend at 70/30 ratio is suggesting that with the addition of 5wt% of SEBS in the optimized blend composition, an increase of 19.97% and 6.90% in tensile modulus and impact strength respectively is observed.

Morphology: It shows the wide angle x-ray diffraction patterns of pure C20A,PP/HIPS blend nanocomposite with and without SEBS. Pure C20A shows adiffraction peak at 2_ =4° corresponding to a d-spacing of 2.42 nm. In case of blend nanocomposites prepared using 3 wt% of C20A, a diffraction peak at 2 = 2.52° corresponding to d-spacing of 3.5 nm was observed. This suggests an increase in the basal spacing of the blend nanocomposites, confirming intercalation of silicate layer at the interface between the two blend component X-ray diffraction.

Corresponding Author: V. Ganesh Ram, Department of Mechanical Engineering, Bharath University, Chennai, Tamil nadu, India.
Dynamic Mechanical Analysis: The dynamic storage modulus (E') versus temperature traces for the recycled HIPS, recycled PP, HIPS/PP blend, HIPS/PP/SEBS and HIPS/PP/C20A. The DMA curves of blend nanocomposite with SEBS have not been taken into consideration in the present study. A gradual decline in E' with increase in temperature from -50 to 150°C was observed in all cases. In case of HIPS/PP blend, incorporation of HIPS results in decrease in the storage modulus of the PP matrix due to incompatibility of the both phases. However, the addition of SEBS and nanoclay resulted in an increase in storage modulus over the entire investigated range of temperature. This increase in storage modulus with addition of SEBS is due to good affinity of PS block of SEBS and PS part block of HIPS. Therefore increase in modulus from 1661 MPa at 25°C to 1928 MPa at 25°C which is in good agreement with the modulus from the static mechanical tests as discussed in the earlier section. Incorporation of organoclay into blend matrix enhances its stiffness thus indicating the reinforcing effect of nanoscale platelets and effective stress transfer at the interphase and also intercalated structure in the blend.

Scanning Electron Microscopy (SEM): It shows the impact fractured surface of recycled 70/30 (PP/HIPS) blend before and after etching in acetone solvent at room temperature for 1 hr. It is evident that small amounts of spherical domain are dispersed in the continuous PP phase after etching in acetone solvent. The voids observed on the surface are believed to be due to the removal of butadiene phase from the HIPS matrix.

Differential Scanning Calorimetry: DSC thermograms of recycled PP, recycled HIPS, PP/HIPS blend (70/30), PP/HIPS (70/30) + (3%) SEBS blend, PP/HIPS (70/30) + 3 wt% C20A and PP/HIPS (70/30) + 3 wt% C20A + 5 wt% SEBS are enumerated in Corresponding crystallization temperature (Tc), melting temperature (Tm), heat of fusion (DH), %crystallization of recycled PP and that of blend. It is observed that the recycled PP shows melting temperature of 165.72°C. Incorporation of HIPS results in marginal decrease in Tm to 164.38°C which further increases to 166.39°C in presence of SEBS. This confirms compatibilization efficiency of SEBS which increases the interfacial area and improves the stress transfer in the system.
Thermograms of PP with HIPS

Thermogravimetric Analysis (TGA): Incorporation of the compatibilizer and nanoclay with and without SEBS resulted in improvement in thermal stability of PP/HIPS blend. The degradation temperature at 10% weight loss (T10) increased from 369.94°C to 373.29°C, 375.23°C and 375.35 with incorporation of SEBS and nanoclay without and with and compatibilizer respectively. The final degradation temperature Tf also increased from 474.64°C to 491.02, 499.02 and 518.62°C with incorporation of SEBS and nanoclay without and with and compatibilizer respectively.

CONCLUSION

The present investigation reports the compatibilization efficiency of SEBS and C20A in recycled PP/HIPS blend and its blend nanocomposites. Following conclusions were derived from our experimental findings. Morphological studies confirmed the evidence of efficient interaction of SEBS and nanoclay at the interface of recycled PP/ HIPS blend, with a decrease in average particle size from 5.078 to 1.724 and 2.082 im respectively. PP/HIPS (70:30) blend compatibilised with 5 wt % and 3 wt % of SEBS and C20A improves the mechanical properties considerably. An increase of 45.13% and 60.73% in impact strength has been observed with addition of SEBS and C20A. DSC studies showed an increase in crystallinity of PP in blend from 20.03 to 23.38 % with addition of 5%SEBS and 3% C20A. TGA studies confirmed an increase in Tf from 474.64°C to 518.62°C. An excessive tri-block co-polymer concentration SEBS and C20A concentration brings observable changes in the property. The compatibilizer and dispersed phase concentration plays a key role in developing multiphase polymers with well-balanced properties. Hence recycled PP/HIPS blend and its nanocomposites can be fabricated for value added products with desired attributes.

REFERENCES