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EVALUATION AND CHARACTERIZATION OF POLYSTYRENE BLENDING WITH POLYPROPYLENE BY USING VARIOUS COMPATIBILIZERS

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ABSTRACT

The use of Polymer based materials (PBM) is rapidly increasing to replace the metal parts because of their lower densities, easy maintenance & inexpensive prices. Among a variety of PBM's PP/PS belong to the most important ones. These blends are suitable for low performance parts like dash boards, computer cases. However they cannot be used for high performance parts like automotive & aviation because they exhibit low impact strength, tensile strength, flexural, compression. To increase the mixture properties suitable chemicals/substances are needed. These chemicals are called as compatibilizers. This study focuses on the exploration of a suitable compatibilizer for the said mixtures. These compatibilizers should be such that the mechanical and thermal properties of the mixture should be enhanced. Blends of 100/0, 75/25, 50/50, 25/75 and 0/100 wt% PP/PS were prepared through melt blending in a Twin screw extruder at a blend temperature of 200°C and a screw speed of 60 rpm. Three compatibilizers, viz. Styrene-Ethylene/Butylenes-Styrene (SEBS), Ethylene Vinyl Acetate (EVA) and Surlyn with concentration of 5% w/w were used. The tensile strength, flexural, compression, impact, strength of blends was compared and Heat Deflection Temperature (HDT), Melt Flow Index and Glass Transition temperature were also compared. The blends containing SEBS and EVA showed a positive effect on the ductility of the blend. In the presence of Surlyn the strength of the blend increased.

KEYWORDS: Polymer Based Materials, Polystyrene, Polypropylene, Styrene-Ethylene/Butylenes-Styrene (SEBS), Ethylene Vinyl Acetate (EVA) and Surlyn

INTRODUCTION

Blending of polymers an efficient way of developing new materials with tailored Properties, and thus has received much attention from academia and industry. By blending different polymers, several properties can be improved, while retaining some of the original properties. The resent study focus on the blending of Polystyrene and Polypropylene. Because individually both are having excellent properties. And PS has many desirable properties, its disadvantage are low impact strength and poor chemical resistance at room temperature, especially to ketons and ethers [1]. Combination of different polymers into multiphase systems represents a very attractive route towards new materials. It is also an efficient way to improve some deficient properties of common plastics [2, 3]. Despite the high performance, the cost of block and graft copolymers, the PS/PP blend system is considered immiscible and incompatible, because PS contains benzene rings and PP contains straight carbon chains of an aliphatic kind. Many are reported compatibilizers are miscibility purpose and these are Styrene-Ethylene/Butylenes-Styrene (SEBS), Ethylene Vinyl Acetate (EVA) and Surlyn here the SEBS is effective compatibilizer because the PS and EB blocks of SEBS are miscible with PS and PP respectively [4-6] .

Generally prevents them from being used on a large scale. Melt blending of immiscible polymers is a more direct and less expensive way to producing multiphase systems. The advantage is however counterbalanced by weak interfacial adhesion and poor stability of the phase dispersion [7-9]. The incompatibility between polymeric components is responsible for the very poor mechanical properties of most polymer blends. When two polymers separate into a two-phase system, the domain size is coarse, irregular, and unstable; moreover the interface is sharp and weak, giving poor properties and practical incompatibility problems. In such a case, the interfacial tension is high and adhesion between the two phases is low, giving poor stress transfer across the interface [10-12]. In other words, a fracture path may preferentially follow the weak interface between the polymer phases, or the fracture initiate at the interface when tension is applied to the specimen. The process of modification of interfacial properties of an immiscible polymer blend leading to the creation of a new blend, which is called compatibilization, has played an important role in the development of polymer blends. Compatibilization by addition of a third component can significantly improve the mechanical properties of the blend by reducing the dispersed phase domain size and by enhancing phase adhesion. Blends of PS/PP exhibit poor mechanical properties owing to the incompatibility of these two polymers. The mechanical properties for such a blend normally improved with the addition of compatibilizers [13-16]. In this work, there are four types of compatibilizers used. Surlyn and ethylene vinyl acetate (EVA) were chosen for this study with the hope of achieving improvements in properties through an affinity and polarity concept. Polystyrene-block– poly (ethylene–butylene)-block–polystyrene (SEBS), on the other hand, was chosen owing to the possible affinity with both components of a PS/PP blend [18]. PS with PS blocks of SEBS and PP with polyolefinic block EB of SEBS [17]. The effects of these compatibilizers on mechanical properties and Thermal properties of PS/PP blends are reported.

EXPERIMENTAL PROCEDURE

Materials

The Polystyrene used was general purpose Polystyrene (GPPS HH-30) supplied by Baedeker plastics. Polypropylene Homo-polymer H110FG Supplied by REPOL. The properties of GPPS HH-30 and H110FG are summarized in table 1.both of these resins were originally in the form of extruded pellets. The compatibilizers used were SEBS, EVA and SURLYN supplied by Kinetic polymers, Hyderabad**.**

Table 1: the properties of GPPS HH-30 and H110FG

Properties	GPPS HH-30	PP-H110FG
Specific gravity(g/cc)	1.1	0.9
Melt Flow Index(g/10 min)	5.4	6.2
Tensile Strength(N/mm^2)	82	40
Flexural strength(N/mm^2)	71	40
Compressive strength(N/mm^2)	98	40
Impact strength(J/m)	126	335
Heat Deflection Temperature(^{0}C)	74	65
Glass Transition Temperature(^{0}C)	98	88

Procedure

- A fixed amount of compatibilizer (No compatibilizer, SEBS, EVA & Surlyn) is added to various fractions of PP/PS mixture & mixed manually in polythene bags.

Tables 2: Samples with different Compatibilizers

S. No	Sample	PS%	PP%	Compatibilizer
1	S1	0	100	0
2	S2	25	75	0

3	S3	50	50	0
4	S4	75	25	0
5	S5	100	0	0

Tables 3: Samples with Different Compatibilizers

S. No	Sample	PS%	PP%	SEBS%
1	S1	0	100	0
2	S2	25	75	5
3	S3	50	50	5
4	S4	75	25	5
5	S5	100	0	0

Tables 4: Samples with Different Compatibilizers

S. No	Sample	PS%	PP%	EVA%
1	S1	0	100	0
2	S2	25	75	5
3	S3	50	50	5
4	S4	75	25	5
5	S5	100	0	0

Tables 5: Samples with Different Compatibilizers

S. No	Sample	PS%	PP%	Surlyn%
1	S1	0	100	0
2	S2	25	75	5
3	S3	50	50	5
4	S4	75	25	5
5	S5	100	0	0

- This compatibilizer added mixture is then extruded in a twin screw extruder, to get a uniform mixture. This extruder is operated at 200^0C and 60 rpm Speed.
- The product, which is a thin thread like, is cut into small pieces by using cutter and is sent to injection molding.
- In injection molding, the required shape of the mold is fixed and the specimen is then injected in the mold.
- Specimen is prepared according to the size required for the testing of mechanical and thermal properties.
- The specimen is tested for different mechanical properties viz., tensile, flexural, compressive and impact strength by using Universal Testing Machine (UTM). Thermal properties are tested by using Heat Deflection Temperature (HDT), Melt Flow Index and Glass Transition Temperature (GTT) apparatus.

Tensile Strength: UTM-ASTMD638

It is defined as the ability of material to be withstand tensile force when pulled apart .it is expressed Kg/cm^2

Tensile strength= $\frac{force(load)N}{cross\ sectional\ area(mm2)}$

The required specimen size is 10mm wide & 150mm long.

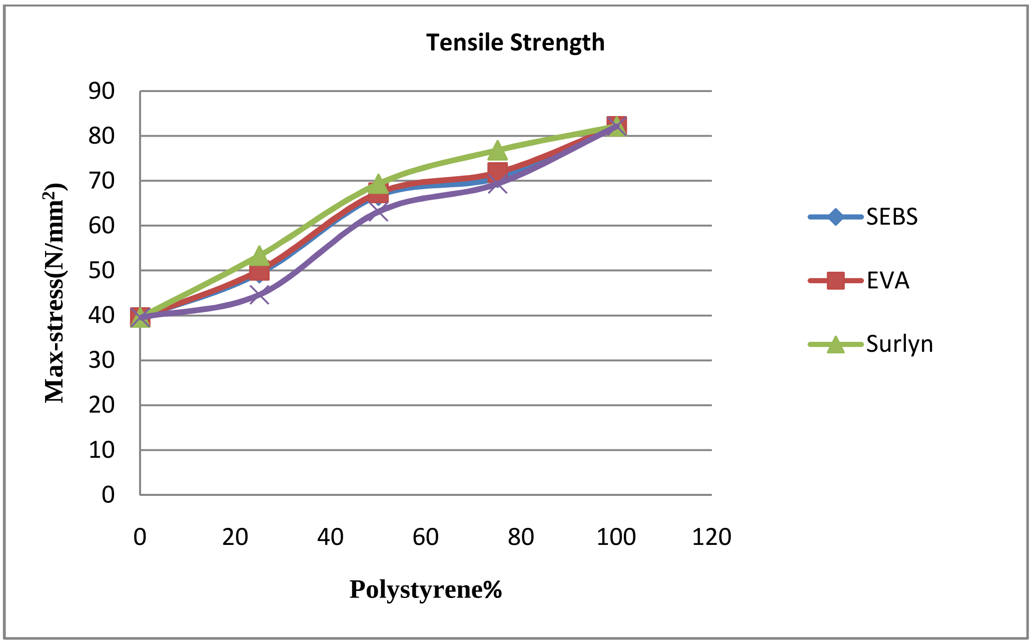

Figure 1: Tensile Strength at Different Compatibilizers (5% w/w) and Different PS/PP Compositions

The properties at high deformation are illustrated in Figure 1. As indicated by the ultimate stress at rupture. Here, the effect of addition of various compatibilizers on the tensile strength is shown for different blend ratios. The addition of SEBS to PS/PP blends reduced the tensile strength for all blend compositions. Since the SEBS is a thermoplastic elastomer, the presence of such a copolymer will reduce the tensile strength of the blend. The addition of EVA and Surlyn to PS/PP blends gave slightly higher tensile strength than the uncompatibilized one for all blend compositions due to the improvement of adhesion and better stress transfer within the blend. The drop in tensile strength of the PS/PP blend by the presence of EVA may be due to a reduction of the crystallinity of the blend as a result of the presence of vinyl acetate in EVA.

Flexural Strength

It is the ability of material to withstand bending forces applied perpendicular to longitudinal axis. It is expressed in Kg/cm^2.

Required specimen size is 12.7mm x 12.7mm x thickness of the product.

Flexural strength = $\frac{3PL}{2bd2}$ Where, P = Load, N

L = Distance of supports, mm

b = width of specimen, mm

d = Thickness of test specimen, mm.

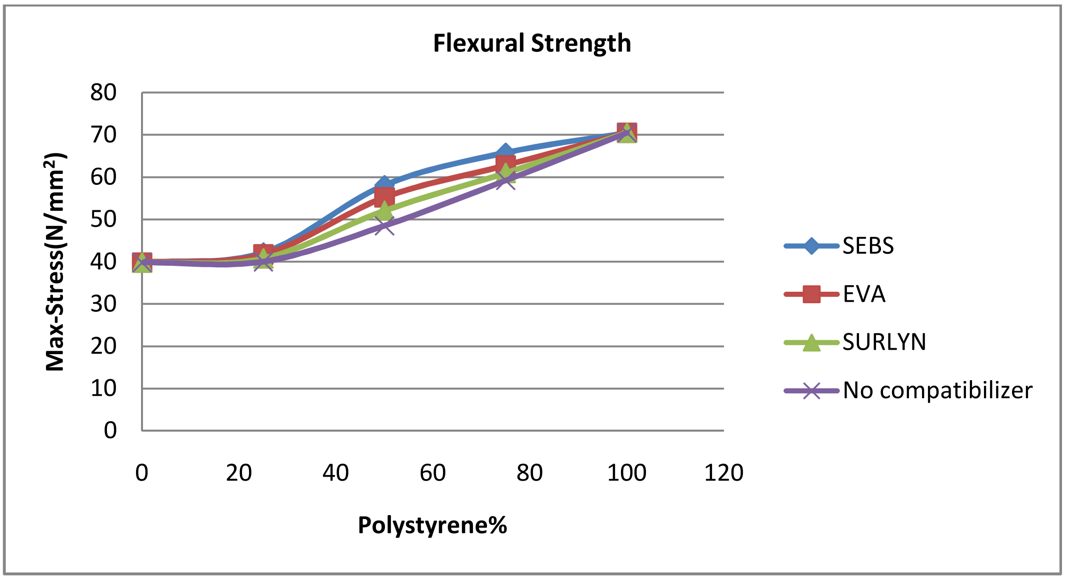

Figure 2: Flexural Strength at Different Compatibilizers (5% w/w) and Different PS/PP Compositions

The effect of addition of various compatibilizers on the flexural strength is shown for different blend ratios in figure 2. It can be seen that the flexural bar charts fall below the additivity rule line for the whole range of compositions. The addition of SEBS to PS/PP blends increases the Flexural strength for all blend compositions. The addition of Surlyn to PS/PP blends gave slightly higher Flexural strength than the uncompatibilized one for all blend compositions due to the improvement of adhesion and better stress transfer within the blend.

Compression Strength

It is the ability of a material to withstand compressive force when loaded at relatively by low & uniform rate. It is the maximum compressive stress carried by the test specimen during a compression test.

Required specimen size is 12.7mm x 12.7 mm x 25.4 mm.

$$\text{Compressive strength} = \frac{Force}{Cross\ sectional\ area\ of\ the\ specimen}$$

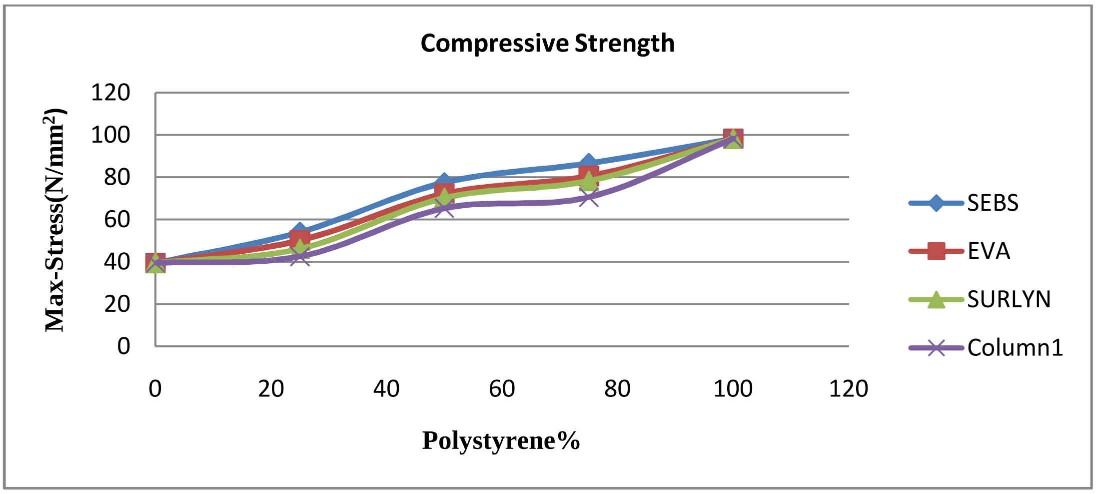

Figure 3: Compressive Strength at Different Compatibilizers (5% w/w) and Different PS/PP Compositions

The effect of addition of various compatibilizers on the compressive strength is shown for different blend ratios. It can be seen that the compressive bar charts fall below the additivity rule line for the whole range of compositions. The addition of SEBS to PS/PP blends increases the Compressive strength for all blend compositions. The additions of Surlyn, EVA to PS/PP blends gave slightly higher Compressive strength than the uncompatibilized one for all blend compositions due to the improvement of adhesion and better stress transfer within the blend.

Impact Strength: ASTMD256

It is defined as the ability of the material to withstand sudden shock load at the time of failure.

Required specimen size 64.5mm x 12.7mm x 3.2mm

Impact strength = $\frac{\textit{Impact energy}}{\textit{cross sectional area of the specimen}}$

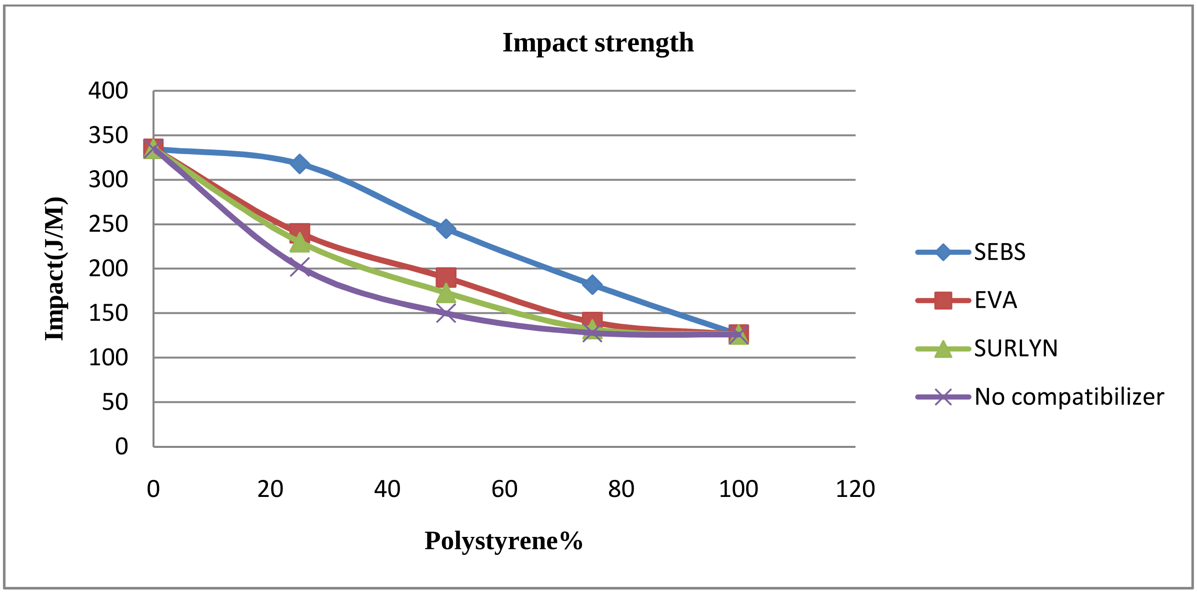

Figure 4: Impact Strength at Different Compatibilizers (5% w/w) and Different PS/PP Compositions

The unnotched impact strength of the blend systems investigated was plotted against the blend composition in Figure 4.Here, the effect of compatibilizers on impact strength is shown at various compositions. In comparison with the uncompatibilized blends, it can be seen that the impact strength of the PS/PP blends increases with the addition of SEBS, Surlyn or EVA as compatibilizer. Due to the presence of SEBS as a thermoplastic elastomer in PS/PP blends the impact strength of such blends improved over the linear additivity line. The positive deviation of impact strength in all blend compositions was exhibited by the presence of SEBS, but the values did not exceed that of pure PP. The increase in toughness is accompanied by an increase in elongation at break, and this effect occurs mainly in the blends containing SEBS. The addition of such a compatibilizer to the PP rich blend has a pronounced effect with the area under the stress–strain curve, i.e. the work to fracture is larger than that found for intermediate or PS-rich blends. The compatibilizers Surlyn and EVA seem to behave in a similar manner to SEBS and produce best impact strength in the PP-rich blend.

Heat Deflection Temperature: ASTMD648

It is defined as the temperature at which a standard test bar of 12.7mm x 12.7mm x 6.4mm deflects 0.01” under stated fiber stress of either 66 PSI or 264 PSI.

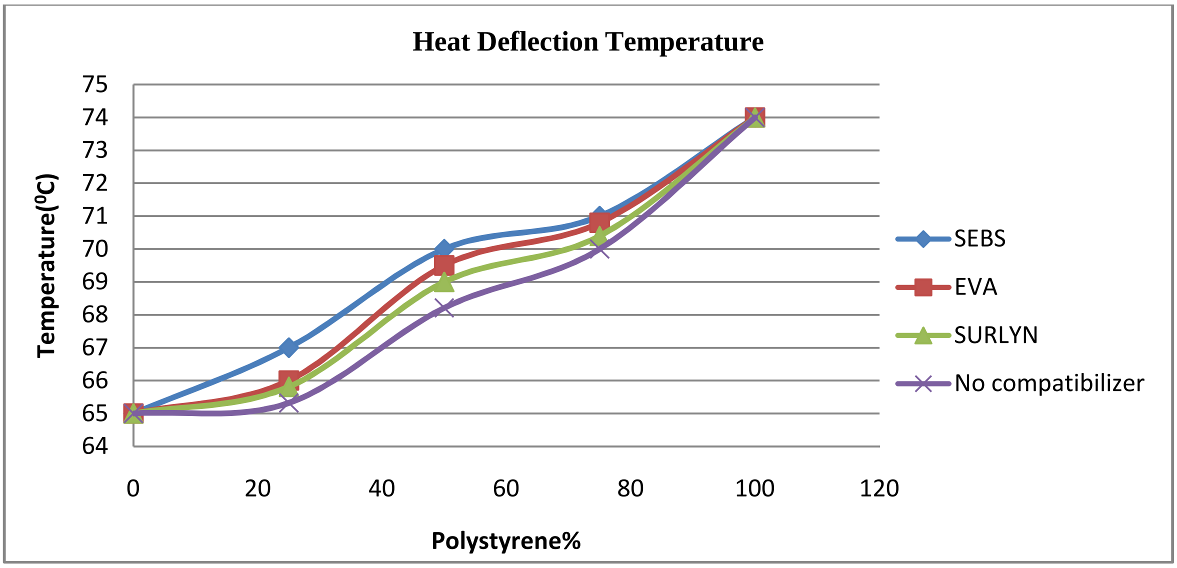

Figure 5: HDT at Different Compatibilizers (5% w/w) and Different PS/PP Compositions

As the PS% raises heat deflection Temperature will also rises has shown above in the plotted Graph. In contrast to EVA, SURLYN, No Compatibilizers Heat Deflection Temperature will be more which has been represented above. As per my observation the best result will be obtained at the condition 75%PS and 25%PP for the SEBS with comparison to the remaining all.

Melt Flow Index: ASTMD1238

It is defined as the rate of extrusion of molten resin under specified temperature and pressure through a specified size of dye in 10min.

Melt Flow Index $=\frac{600*M}{t}$, (gm/10min) Where, M = avg. mass, gm t = cut- off time, min

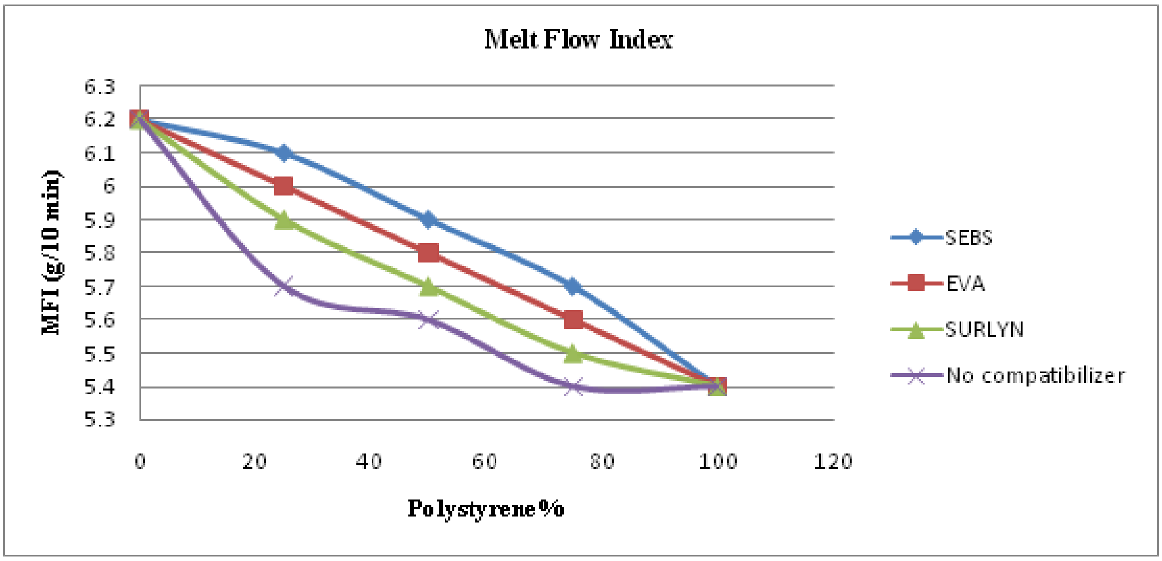

Figure 6: Flexural Strength at Different Compatibilizers (5% w/w) on Different PS/PP Compositions

SURLYN will give best Melt Flow Index as the graph illustrates by the comparison with the other factors When the PS% increases the melt flow rate decreases where the EVA, SEBS and without compatibilizer. Utmost results have been noticed with SURLYN here the conditions 75% PS and 25% PP because Surlyn have week bandings.

CONCLUSIONS

- In conclusion, it can be stated that those blends with 5% SEBS produce an improvement in toughness of PS/PP blends for all blend compositions. Moreover, the brittle behavior can be converted into a quite ductile material in all PS/PP blends with the addition of SEBS.
- The addition of 5% Surlyn increased the tensile strength of the all blend compositions. EVA and SEBS gives somewhat well than without compatibilizer.
- Flexural and compressive strength increases with increase in PS composition as compatibilizer is SEBS In the case of adding 5% of SEBS in PS/PP blend.
- The Impact strength will be decreases with increase in PS composition. Impact strength will be good at more PP composition with 5%SEBS compatibilizers.
- Heat deflection temperature is increased with increasing PS composition and 5%SEBS is shown best result.
- Melt flow Index will be more at 5% Surlyn and decreases with increase in PS composition.
- After several experiments75% PS and 25% PP with 5%SEBS will give mechanical and thermal properties.

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