

USE OF ORGANICALLY MODIFIED MONTMORILLONITE IN THE PREPARATION OF IMPACT MODIFIED POLYSTYRENE

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Introduction

There are many ways for the impact modification of brittle polymers, among those; melt blending of polymers with thermoplastic elastomers is one of the cheapest and easily handled processes for specific applications. However, the reduced strength and stiffness of the material hinders its practical usage.

Clay particles attracted much attention in recent years owing to their layered crystalline structure, making them suitable fillers for forming nanocomposites. Dispersion of small amount of clay particles leads to significant improvements in many properties such as; strength, stiffness, thermal stability, and barrier properties [1, 2]. However, to achieve an expected performance, it is important to disperse the clay layers homogeneously.

Due to the incompatibility between the non-polar polymers and hydrophilic clay layers, organic modification of the layers is essential. Moreover, thermoplastic elastomers, used to improve the impact strength, increase the compatibilization and hence the interaction of clay surface with the thermoplastic melt [3].

Many studies have been reported on the synthesis of PS/clay nanocomposites or PS/Elastomer blends [4-6]. In this study, our primary goal is to improve the toughness of PS without deteriorating other mechanical properties.

Experimental

Materials:

As the polymer matrix, commercial PS with a trade name Lacqrene®1960N (Total Petrochemicals) was used.

SEBS-g-MA (Kraton® FG1924X) was used as the elastomer. It is a clear linear tri-block copolymer based on styrene and ethylene/butylene and its content was varied from 5 to 40 wt%.

The organophilic clay of MMT (Cloisite® 25A), purchased from Southern Clay Products, was used as filler. The surfactant used by the manufacturer for organic modification is dimethyl, dehydrogenated tallow, 2-ethylhexyl quaternary ammonium cation (2MHTL8). The content of the clay was kept constant at 2 wt% in our experiments.

Preparation of Nanocomposites:

A co-rotating Thermo Prism TSE 16 TC twin screw extruder (L/D = 25) was used for melt intercalation. During the extrusion process, the

temperature profile from feed zone to the die, feed rate and screw speed were kept constant at 200°C, 25g/min and 300rpm respectively. Pellets obtained by extrusion were molded with a laboratory scale injection molding machine by keeping the mold at 30°C and melt at 200°C.

Measurements:

Rigaku D/MAX 2200/PC based X-ray diffractometer, equipped with Cu-K radiation, was used to analyze the composites ($\lambda = 1.54 \text{ \AA}$, generator tension = 40 kV, generator current = 40 mA).

The fracture surfaces of specimens were etched with n-Heptane at room temperature and the images were observed by SEM using a JEOL JSM-6400 low voltage scanning electron microscope. For TEM analysis, Phillips CM200 Transmission Electron Microscope was used at an acceleration rate of 120 kV. The samples were cryogenically cut at 100°C.

Tensile tests were performed by using a Lloyd 30 K Universal Testing Machine following the procedure specified in ASTM 638-M 91a. Pendulum Impact Tester of Coesfeld Material Test was used for impact tests according to the test Method-I, procedure A in ASTM D256-91a.

Results and Discussion

XRD Results:

According to the XRD pattern, Cloisite® 25A has a basal spacing of $d = 18.7 \text{ \AA}$. When the organoclay particles were introduced into PS matrix, they remain as tactoids with intercalated polymer chains inserted between the layers. In addition, as opposed to the XRD pattern of pure Cloisite® 25A, a second peak is observed owing to a second silicate layer with a d-spacing value of approximately twice that of the first characteristic peak (Figure 1).

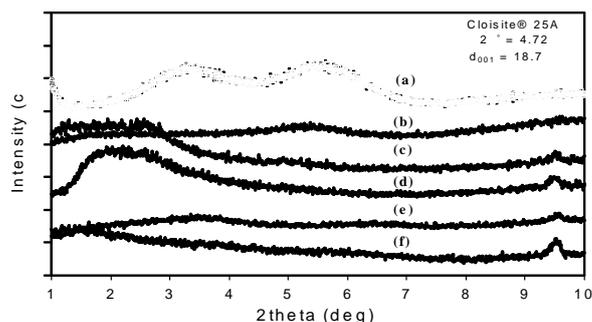


Figure 1. XRD pattern of nanocomposites containing; PS, 2 wt% Cloisite® 25A, and SEBS-g-MA; (a) 0 wt%, (b) 5 wt%, (c) 15 wt%, (d) 20 wt%, (e) 30 wt%, (f) 40 wt%.

With the addition of elastomeric phase, no diffraction peak is observed, indicating exfoliated structures. For the nanocomposites containing 15 and 20 wt% SEBS-g-MA, XRD patterns show unexpected oscillations that can be due to agglomeration of clay particles. However, with TEM analysis the homogeneous dispersion of the tactoids in the presence of elastomeric material was observed.

TEM Results:

To validate the morphology of the nanocomposites, the structure was observed with TEM analysis. As can be seen from Figure 2.a the binary nanocomposite shows the sparse presence of primary particles of clay in the polymer matrix with closely stacked clay layers, indicating intercalation by polymer chains, in accordance with the XRD results.

When, the compatibilizer is used, the clay layers are dispersed more uniformly and they even delaminate. However, the nanocomposite containing higher amount of SEBS-g-MA (15wt%) shows a better dispersion of clay platelets.

Another observation from TEM analysis is that, the clay particles are localized both at the interphase between the PS and the elastomeric phase and inside the elastomeric phase.

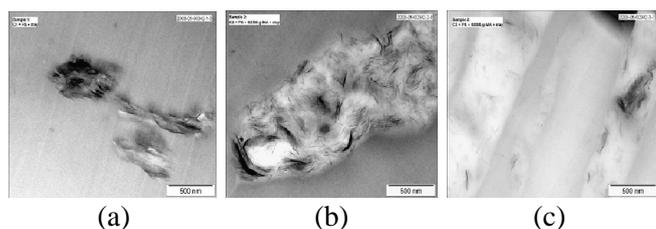


Figure 2. TEM image of nanocomposites containing; PS, 2 wt% Cloisite® 25A, and SEBS-g-MA; (a) 0 wt%, (b) 5 wt%, (c) 15 wt%

SEM Results:

To examine the elastomeric particle size and their distribution, SEM analysis was used. As can be seen from the SEM images of the etched fractured surface of the binary blends (Figure 3), the elastomeric domain size increases with increasing elastomer content as expected. As a result of increasing elastomer content, co-continuous phase morphology forms at “phase inversion” point. For PS/SEBS-g-MA blend, this point is between 30 and 40wt% elastomer content.

When organoclay is introduced, an increase in the average dispersed particle size was observed owing to the dispersion of clay particles both at the interphase and in the elastomer phase. Effect of organoclay addition on elastomeric domain size can be seen from Figure 4. If the organoclay particles were dispersed in the PS matrix, the clay platelets would suppress the agglomeration of the elastomeric domains and cause a barrier effect that hinders the recombination of elastomeric domains. However, in this case, the opposite is observed and the phase inversion point shifts to lower elastomer contents.

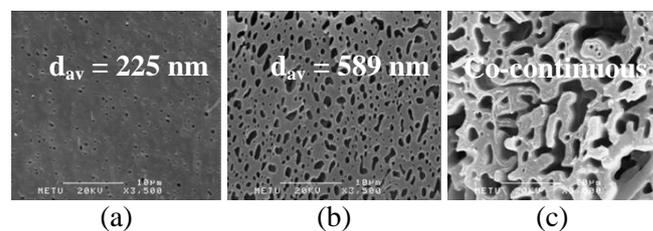


Figure 3. SEM image of binary blends containing PS, and SEBS-g-MA; (a) 5 wt%, (b) 20 wt%, (c) 40 wt%

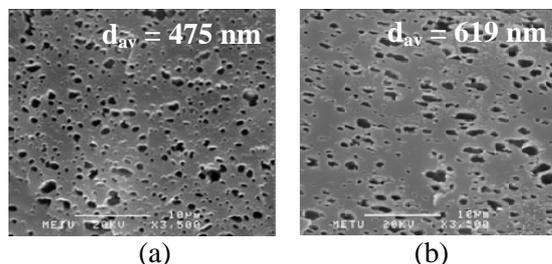


Figure 4. SEM image of composites containing PS, 15 wt% SEBS-g-MA, and Cloisite® 25A (a) 0 wt%, (b) 2 wt%

Mechanical Test Results:

According to impact and tensile tests, as the elastomer content increases the toughness and the elongation at break values of the nanocomposites increase as expected. However, at 30 and 40 wt% elastomer content, the strength and stiffness of the materials show a drastic reduction. Thus, it can be stated that the nanocomposites containing 15 and 20wt% SEBS-g-MA have the optimum average elastomeric domain size that results in better impact strength values with undisturbed tensile properties.

Conclusion

Exfoliated structure of Cloisite® 25A particles were observed in ternary nanocomposites which leads to improved mechanical properties. By using elastomeric material, the compatibilization between PS and clay particles was achieved and the impact strength was improved. In summary, the toughness of PS was improved without deteriorating other mechanical properties by using an optimum elastomer content of approximately 15-20 wt%.

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