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INFLUENCE OF TALC INCORPORATION ON THE THERMAL PROPERTIES OF POLYSTYRENE COMPOSITES

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ABSTRACT

In this contribution, we report the variation of thermal properties of polystyrene composites reinforced with talc powder. Our films were obtained by melt compounding using a single screw extruder and analyzed using both differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). The results obtained are well discussed.

Key words: Polystyrene, Talc, Composite, Thermal properties, Extruder, DSC, TGA.

INTRODUCTION

Polystyrene (PS), is one of the most commonly used thermoplastic polymers. It can be found in numerous daily applications (packaging, electronic applications, foam, appliance components, toys and insulate building panels)[1]. However, the polystyrene exhibits poor solvent resistance, brittleness and poor thermal stability properties that make it unsuitable for certain applications like as flame retardant[2].

Since many years, the polystyrene thermal stability has gained amount attention in research to ease the elaboration processing and ensure a better performance during its possible applications. In a recent research, it was reported that the graphene oxide GO can enhance the thermal stability of polystyrene matrix[3] and in other one, multi walled carbon nanotubes incorporation in the same matrix lead to significant increase of its thermal stability[4].

Polystyrene polymer composites reinforced with mineral fillers have known considerable interest due to their enhanced properties and cost reduction. Cheng et al.[5] have

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reported good mechanical and thermal properties for the polystyrene matrix after the incorporation of mica.

Among a lot of minerals, talc is an optimum one distinguished by low cost, excellent thermal stability and chemical inertness. It is used in numerous industries; in plastics, paints and rubbers, cosmetics[6]. The studies on talc based polymer composites showed improved physical and thermal properties[7].

The reports on polystyrene matrix indicated that its composites can be elaborated by different methods including solution method, in-situ polymerization and the melt compounding, which a successful elaboration method known in the field of thermoplastics manufacturing.

In this approach, the polymer matrix and the other additives such as filler are mixed together using single/twin screw extruder device under the effect of shear forces and temperature[8].

In this paper, polystyrene composites including 0, 5, 10 and 15% by weight of talc were synthesized by melt compounding using a single screw extruder. The effect of talc incorporation on thermal behavior of PS/Talc composites was studied using both of thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC).

EXPERIMENTAL

Materials

The resin used in our study is atactique polystyrene supplied by Total Petrochemicals Company, Spain, E-U. The natural talc was obtained from Turkish Omyatalc (Omya Madencilik AS). The polystyrene pellets were grinded to ease the blending process with talc.

Samples elaboration

The polystyrene/talc composites films containing 0, 5, 10 and 15% by weight of talc were obtained by extrusion process. Both of the polystyrene powder and the talc powder were mixed using a commercial mixer at room temperature. The final mixture of each formulation was extruded using single screw extruder lab scale Plasti-Corder PLE 330 adjusted at a barrel temperature of 175°C and screw speed of 30 r.p.m.

Samples characterization

DSC analysis

DSC analysis was carried out to study the glass transition temperature (T_g) variations of our composites using a Metler Toledo DSC 1 star system. The samples were heated from 30 to 140°C with heating rate of 10°C/min.

Thermogravimetric analysis

The studied composites were the subject of thermogravimetric analysis (TGA) in order to estimate their stability using a TGA/DTA Metler Toledo. The sample weight was around 5 mg. The sample was heated from 35 to 580°C with heating rate of 10°C/min.

RESULTS AND DISCUSSION

Visual observation

The pure polystyrene and polystyrene/talc composites films obtained by extrusion are shown in Fig. 1. It can be seen that these films are of good quality; this is approved by the absence of macro-agglomerates in the surface of the films, which confirms the compatibility between the polystyrene powder and the talc powder as well as the grinding efficiency.

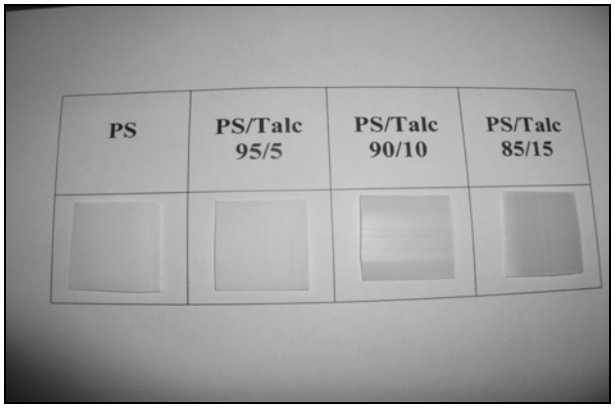

Fig. 1: Physical appearance of pure polystyrene and polystyrene/talc composite films

Differential scanning calorimetry results

The effect of talc incorporation on polystyrene composites glass temperature has been studied in the temperature range between 30 and 140°C by differential scanning

calorimetry (DSC). The DSC thermograms corresponding to both of pure polystyrene and it composites films present approximatively the same form (Fig. 2). The glass transition temperature values for each formulation are given in Table 1.

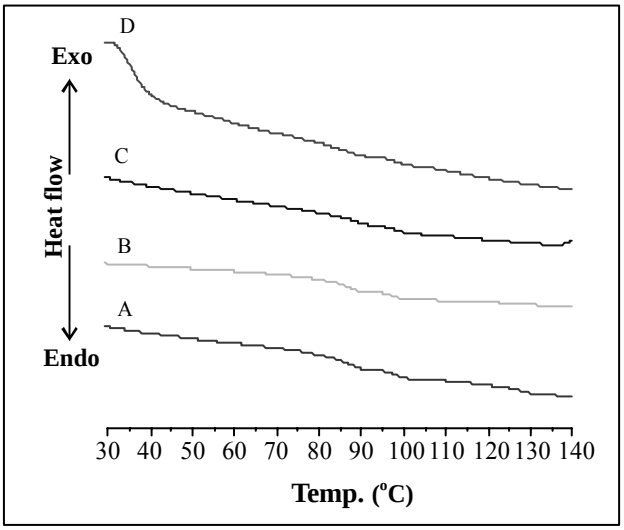

Fig. 2: DSC thermograms; (A) pure PS, (B) PS reinforced by 5 % of talc, (C) PS reinforced by 10 % of talc, et (D) PS reinforced by 15 % of talc

Table 1: Glass transition temperature corresponding to the pure polystyrene and PS/Talc composites

Formulation (%)	T_g(C°)
Pure PS	96.48
PS/Talc (95/5)	88.60
PS/Talc (90/10)	85.77
PS/Talc (85/15)	83.19

It is apparent that the introduction of different proportions of talc in the polystyrene matrix leads to lower the glass transition temperature. This is due to the existence of talc particles between the polystyrene matrixchains; which increases the free volume between these polymers chains that tends to decrease the glass transition temperature. A similar thermal behavior was reported by Khezri et al.[9] who studied the effect of Cloisite 30 B clay incorporation on the properties of polystyrenecomposites.

Thermogravimetric analysis results

The impact of talc addition on the thermal stability of our studied composites was evaluated by thermogravimetric analysis. The studied samples were heated from 35 to 580°C with a heating rate of 10°C/min. The TGA curves for the analyzed films are illustrated in Fig. 3.

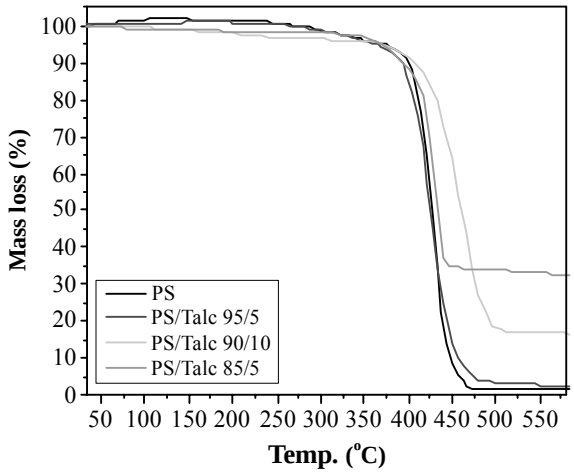

Fig. 3: TGA curves of the neat polystyrene and it composites reinforced by different loading levels of talc

One step of degradation was observed for the both of neat polystyrene and PS/Talc composites; this confirmed a similar degradation process for all studied samples. The different thermal parameters of degradation for each formulation are given in the following Table.

Table 2: Thermal degradation parameters of neat PS and PS/Talc composites

Formulation	IDT (C°)	$T_{20\%}$ (C°)	$T_{50\%}$ (C°)	$T_{75\%}$ (C°)	Residue (%)
PS	372.30	412.42	426.74	437.15	1.59
PS/Talc 95/5	364.22	407.13	426.10	440.09	2.71
PS/Talc 90/10	374.79	432.55	460.39	484.61	16.74
PS/Talc 85/15	370.57	417.30	432.79	-	32.8

Knowing that :

IDT : Initial decomposition temperature: the temperature at 5% of mass loss[10].

$T_{20\%}$: The temperature at 20% of mass loss.

$T_{50\%}$: The temperature at 50% of mass loss.

$T_{75\%}$: The temperature at 75% of mass loss.

Residue: The final amount after the end of the heating.

It can be seen from the previous table that talc can delay the degradation process of the polystyrene matrix. This is approved from the increased thermal parameters compared to those of the neat polystyrene. The decomposition residues are significantly higher with the increase of talc loading level in the formulation. The sample filled by 10% of talc exhibit the best thermal parameters.

CONCLUSION

Polystyrene composites including 0.5, 10, 15% by weight of talc were successfully synthesized by melt compounding. DSC and TGA analysis were performed to understand the effect of talc addition on thermal properties of polystyrene matrix. It was concluded from DSC results that the incorporation of talc lead to decrease the glass transition temperature. TGA demonstrated that the polystyrene thermal stability was enhanced after talc addition especially at 10% loading level.

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