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Dynamic Mechanical Analysis for Waste Tires Reinforced Polystyrene: Shear Compliance

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Abstract: *Polystyrene/waste tires composites were prepared in this study by incorporating small particles of waste tires into polydisperse commercial polystyrene (PS) in a melt-mixing method. The dynamic mechanical properties of PS and PS/composite were studied using ARES-Rheometer under nitrogen atmosphere in parallel plate geometry with diameter 8 mm. The measurements were carried out over a wide range of temperatures ranged from 120°C to 220°C and frequencies from 100 to 0.1 radians per second. The shear compliance of PS composite were studied and compared with those of unfilled PS. The shear compliance were studied and evaluated. Where the values of* J' *at* ω *= 0.06 radians/s are* 1×10^{-4} *and* 5.3×10^{-5} Pa^{-1} *for PS and PS composite, respectively At* ω *= 0.1 radians/s the addition of the rubber alters the value of* J'' *from* 1.6×10^{-4} *to* 8.4×10^{-5} Pa^{-1}*. That means the stability of PS is enhanced by the incorporation of the rubber*

Keywords: Polystyrene composite, Waste tires, Dynamic mechanical spectroscopy, Shear Compliance.

1. Introduction

Composite materials are created by combining two or more components to achieve desired properties, which could not be obtained with the separate components. The use of reinforcing fillers, which can reduce material costs and improve certain properties, is increasing in thermoplastic polymer composites. The advantages of polymer composites on performance, economy, or ecology have accelerated the research activities in the field of polymer composites in terms of academic and industrial interests [1-18].

Disposal of waste rubber material is a global problem, and used tires constitute the largest volume of scrap rubber. Recycling of waste tires is essential due to economic and environmental reasons. Utilization of ground waste rubber has been reviewed recently. Finely ground waste tire rubber has been used as filler in rubbers and in thermoplastics [19]. Physical properties and processability are reported to be adversely affected when large volumes of waste rubber is added to a rubber compound.

The purpose of this work was to characterize in details the shear compliance of rubber filled polystyrene compared to the original material of unfilled polystyrene.

2. Experimental Section

Samples preparation and characterization

PS/waste tires composite was prepared by introducing waste tires into commercial PS with molecular weight about 2×107 g/mol. The waste tires were shredded into small particles sizes of about 2 mm. The mixture of PS and 12 wt % shredded tires are dry mixed by hand-mixing for around half an hour and heated at 300°C for 2 hours. Followed by preparation the samples of filled and unfilled PS for the rheological measurements under compression-mold at 190°C for 3 hours and 15 bars in a disc form with diameter 8 mm and thickness 2.2 mm.

3. Measurements

The dynamic mechanical measurements were performed for PS and PS composite by using an ARES-Rheometer (Rheometric Scientific). The rheometer was operated in the dynamic mode on the plate-plate geometry of 8mm diameter and about 2 mm gap. The gap size changes with the temperatures and is read electronically and allows absolute moduli to be determined. The measurements were performed in this study for the samples under nitrogen atmosphere, strain amplitude 1%, over temperature ranged from 120 to 220°C and angular frequency (ω) varied from 10^2 to10^{-1} radian/s.

4. Results and Discussion

Figures 1-2 give the dynamic data of filled and unfilled PS at various frequencies and temperatures along with the constructed master curves for J' and J'' as a function of the reduced frequency (Wa_T). $J'(\omega)$ is a measure of the energy stored and recovered per deformation cycle, therefore is called the storage compliance. $J''(\omega)$ is a measure of the energy dissipated as heat per cycle of the sinusoidal deformation, for that is called the loss compliance. The Master curves of $J'(\omega)$ and $J''(\omega)$ show three regions because of the wide range of the temperatures at which the samples were measured. These regions are the same as in the G* (ω) curves as explained above. The values of $J'(\omega)$ and $J''(\omega)$ for PS are changed by the addition of the rubber filler in particular at low frequencies as shown in Figures 1-2. These Figures show significant enhancement in the moduli for filled PS at low frequencies which are associated to the melt (flow) regime at high temperatures. Where the values of J' at $\omega = 0.06$ radians/s are 1×10^{-4} and 5.3×10^{-5} Pa^{-1} for PS and PS composite, respectively as shown in Figure 5. And in Figure 6 at $\omega = 0.1$ radians/s the addition of the rubber alters the value of J'' from 1.6×10^{-4} to 8.4×10^{-5} Pa^{-1}. That means the stability of PS is enhanced by the incorporation of the rubber. Because the increase in the stiffness and strength of the PS chains by the addition of the rubber. The significant increase at low frequencies (means at long time and high temperature) may be due to the formation of the rubber-PS network. Since the formation of this matrix increases with the time at high temperature. That is confirmed in the dynamic shear compliances J' and J'' as seen in Figures 1-2.

5. Conclusion

In this study the waste tires reused in the production of PS composite. The dynamic mechanical properties for PS composite are evaluated and compared to those of the original material of unfilled PS. These properties are determined by ARES Rheometer under nitrogen atmosphere in parallel plate geometry with diameter 8 mm. The measurements are carried out over a wide range of temperatures, ranged from 120°C to 220°C and frequencies from 100 to 0.1 radians per second. The shear compliance were studied and evaluated. Where the values of J' at $\omega = 0.06$ radians/s are 1×10^{-4} and 5.3×10^{-5} Pa^{-1} for PS and PS composite, respectively At $\omega = 0.1$ radians/s the addition of the rubber alters the value of J'' from 1.6×10^{-4} to 8.4×10^{-5} Pa^{-1}. That means the stability of PS is enhanced by the incorporation of the rubber

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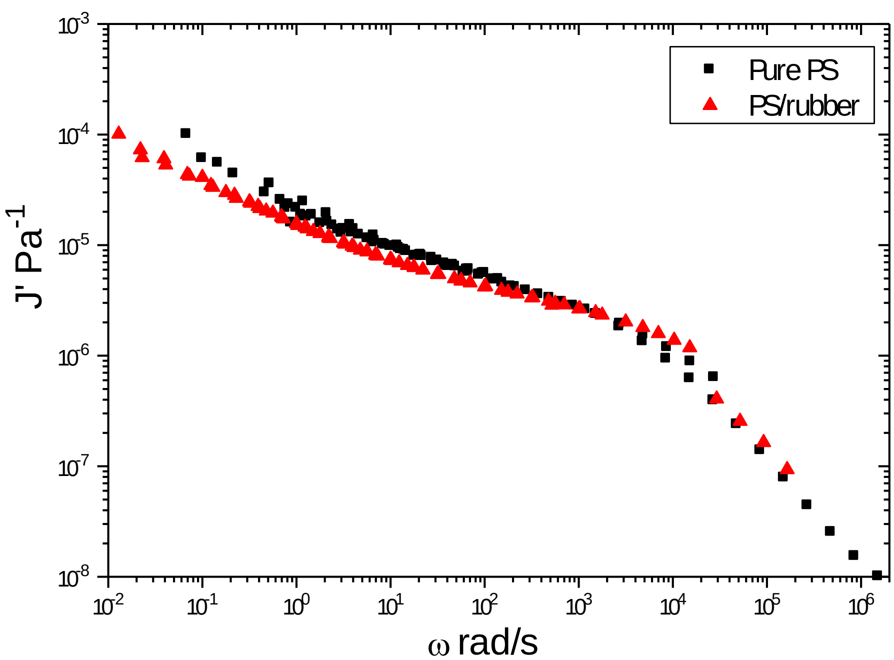

Figure 1: Master curve of J' as a function of ω for PS and PS composite at T_0 = 180°C

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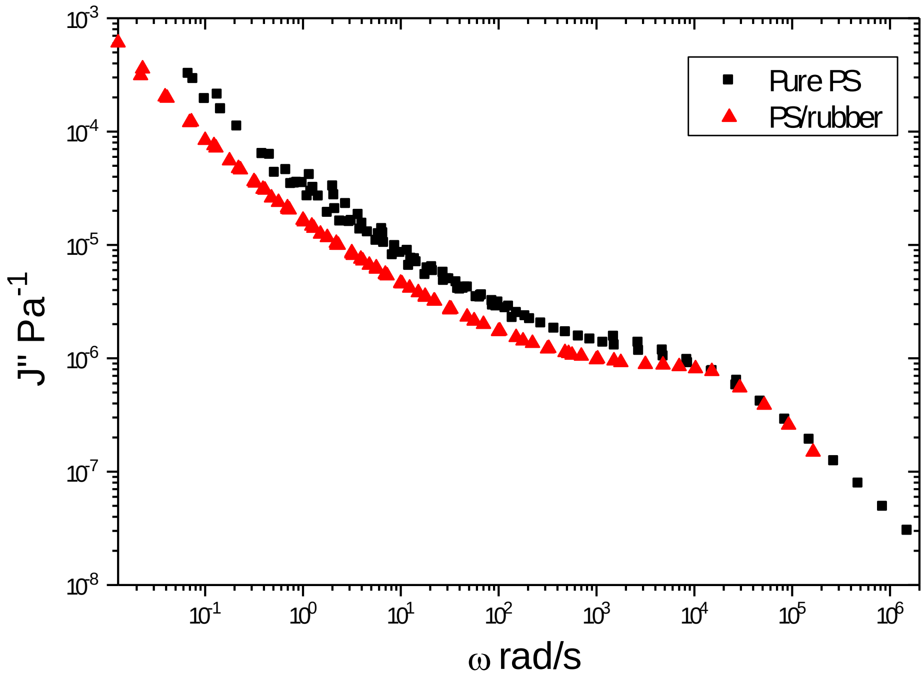

Figure 2: Master curve of J'' as a function of ω for PS and PS composite at T_0 = 180°C.