

Molecular Characterization of Polystyrene/ Waste Tires Composites

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Abstract— In this work, polystyrene/waste tires composites were prepared using the melt-mixing method. The effect of the preparation conditions of the PS/waste tires composite is investigated in this work by using Gel permeation chromatography (GPC) technique.

Stability at elevated temperatures were found to increase with the addition of waste tires to PS as confirmed by the results. GPC results indicate that the preparation conditions of the PS/waste tires composite has no effect on the Ps chains as indicated by GPC technique. The signals of the GPC for unfilled and filled PS are similar. That evidences no thermo-mechanical chain degradation is taken place during the addition of the waste tires under the conditions of the melt-mixing process

Keywords: Polystyrene/waste tires composites, Molecular weight and molecular weight distribution

1. INTRODUCTION

The growth rate of the use of particulate filled polymers is very fast in all fields of application Household articles and automotive parts are equally prepared from them. In the early stages, the sole reason for the introduction of fillers was to decrease the price of the polymer. However, as a result of filling all properties of the polymer change, a new polymer is in fact created. Some characteristics improve, while others deteriorate, and properties must be optimized to utilize all potentials of particulate filling. Optimization must include all aspects of the composites from component properties, through structure and especially interactions [1].

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 [2-18].

Currently, various inorganic materials such as talc, mica, clay, glass fiber, and calcium carbonate are being incorporated into thermoplastic composites [18]. Nevertheless, agricultural fillers, for example, wood fiber or wood flour, have drawn attention due to their abundant availability, low cost, and renewable nature. In recent years, interest has grown for composites made from wood flour or wood fiber in thermoplastic matrices, particularly for low-cost/high-volume applications.

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.

Understanding the makeup of a polymer is particularly important due to the variety of resins available for the same purpose, the high cost of specialty resins or compounds, and the value added to the polymer during manufacturing. For example, the cost of a resin used in a printed circuit board is very low, but the cost of the finished board is very high. Poor quality resin can result in an unacceptable finished circuit board.

Gel permeation chromatography (GPC) is one of the most powerful and versatile analytical techniques available for understanding and predicting polymer performance. It is the most convenient technique for characterizing the complete molecular weight distribution of a polymer.

Waters commercially pioneered GPC in 1963. Since then, Waters has continued to develop and explore new GPC applications and improve the instrumentation that makes GPC so powerful.

The purpose of this work was to study the molecular characteristics of polystyrene/waste tire composites compared to the original material of unfilled polystyrene.

2. EXPERIMENTAL PART

2.1 Samples preparation and characterization

PS/waste tires composites were prepared by introducing waste tires into commercial PS with molecular weight about 2×10^7 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.

The unfilled and filled PS are characterized by Gel permeation Chromatography (GPC) operates at 25°C with tetrahydrofuran as the mobile phase and standard Polystyrene as a calibration standard. GPC samples were prepared by dissolving about 3 mg of the material in 4 ml tetrahydrofuran. The sample was filtered using 0.2 μ m filter Teflon to remove un-dissolved material followed by injecting the sample and run the GPC test.

3. RESULTS AND DISCUSSION

Gel permeation chromatography (GPC) is one of the most powerful and versatile analytical techniques available for understanding and predicting polymer performance. It is the most convenient technique for characterizing the complete molecular weight distribution of a polymer.

Where a polymer's end-use application requires precision performance or endurance under harsh conditions, the need for polymer characterization is particularly acute. Because GPC fulfills these needs better than any other single technique, it has become an extremely valuable tool for materials characterization in the polymer industry.

GPC separates molecules in solution by their "effective size in solution.

Inside the gel permeation chromatograph, the dissolved material is injected into a continually flowing stream of solvent (mobile phase). The mobile phase flows through millions of highly porous, rigid particles (stationary phase) tightly packed together in a column. The pore sizes of these particles are controlled and available in a range of sizes.

The width of the individual peaks reflects the distribution of the size of molecules for a given resin and its components. The distribution curve is also known as the molecular weight distribution (MWD) curve. Taken together the peaks reflect the MWD of a sample. The broader the MWD, the broader the peaks become and vice versa. The higher the average molecular weight, the further along the molecular weight axis the curve shifts and vice versa.

The effect of the preparation conditions of the PS/waste tires composite is investigated in this work by using Gel permeation chromatography(GPC) technique and indicated in Figures 1 and 2. As shown in these Figures, the signals of the GPC for unfilled and filled PS are similar. That evidences no thermo-mechanical chain degradation is taken place during the addition of the waste tires under the conditions of the melt-mixing process. Since obviously, the thermo-mechanical degradation associated with large molecular weight distribution which appears in the shifting of the GPC signal toward high retention volume. Where the broken molecules (small chains) appears at high retention volume (long time), because it takes long time to diffuse into the pores of the gel through the GPC column.

4. CONCLUSION

In this study the waste tires reused in the production of PS composite.

GPC results indicate that the preparation conditions of the PS/waste tires composite has no effect on the Ps chains as indicated by GPC technique. The signals of the GPC for unfilled and filled PS are similar. That evidences no thermo-mechanical chain degradation is taken place during the addition of the waste tires under the conditions of the melt-mixing process

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REFERENCES

1. B.Pukanszky, E.Fekete, “ **Adhesion and surface modification**”, Advances in Polymer Science, V139, P.110-153, Springer-Verlag Berlin Heidelberg, 1999.
2. Andries Voet , “**Reinforcement of elastomers by fillers: Review of period 1967-1976**”, J. of Polymer Science: Macromolecular Reviews, V15, P.327-373, 1980.
3. R. P. Kumar, M. L. Amma, S. Thomas, “**Short sisal fiber reinforced styrene-butadiene rubber composites**”, J. of Applied Polymer Science, V58, P.597-612, 1995.
4. V. M. Murty, S. K. De , “**Short-fiber-reinforced styrene-butadiene rubber composites**”, J. of Applied Polymer Science, V29, P. 1355-1368, 1984

5. J.George, S. S. Bhagawan, N. Prabhakaran, S. Thomas, “**Short pineapple-leaf-fiber-reinforced low-density polyethylene composites**”, J. of Applied Polymer Science V57, P.843-854,1995
6. V. M. Murty, S. K. De ,”**Effect of particulate fillers on short jute fiber-reinforced natural rubber composites**”,J. of Applied Polymer Science,V27, P.4611-4622, 1982
7. D. Nabi Saheb, J. P. Jog ,”**Natural fiber polymer composites: A review**” Advances in Polymer Technology,V18, P.351-363,1999
8. E. Ruckenstein, L.Hong , “**Conducting rubberlike copolymer-carbon fiber composites**”, J.of Applied Polymer Science,V53, P.923-932, 1994.
9. K. L. Fung, R. K.Li, S. C. Tjong , “**Interface modification on the properties of sisal fiber- reinforced polypropylene composites**”, J.of Applied Polymer Science,V85, P.169-176, 2002
10. S.K.Kutty, G. B. Nando , “**Short kevlar fiber-thermoplastic polyurethane composite**”, J. of Applied Polymer Science, V43, P.1913-1923, 1991
11. Wolfgang G. Glasser, Razaina Taib, Rajesh K. Jain, Ron Kander, “**Fiber-reinforced cellulosic thermoplastic composites**”, J. of Applied Polymer Science, V73, P.1329-1340, 1999
12. M.Shibata, K.Ozawa, N.Teramoto, R.Yosomiya, H.Takeishi, “**Biocomposites Made from Short Abaca Fiber and Biodegradable Polyesters**” Macromolecular Materials and Engineering, V288, P.35-43, 2003
13. R. S. Rajeev, A. K. Bhowmick, S. K. De, S. Bandyopadhyay , “**Short melamine fiber filled nitrile rubber composites**”, J.of Applied Polymer Science, V90, P.544-558, 2003
14. C.Vajrathira, T.Amornsakchai, S. Bualek-Limcharoen, “**Fiber-matrix interactions in aramid-short-fiber-reinforced thermoplastic polyurethane composites**”, J.of Applied Polymer Science, V87, P.1059-1067, 2003
15. M.A. Martins, I. Joekes, “**Tire rubber-sisal composites: Effect of mercerization and acetylation on reinforcement**”, J.of Applied Polymer Science V89, P.2507-2515, 2003
16. V. G. Geethamma, R. Joseph, S.Thomas,“**Short coir fiber-reinforced natural rubber composites: Effects of fiber length, orientation, and alkali treatment**” J. of Applied Polymer Science,V55, P.583-594, 1995
17. D. K. Setua, B. Dutta, “**Short silk fiber-reinforced polychloroprene rubber composites**”,J.of Applied Polymer Science,V29, P.3097-3114, 1984
18. J.Son, D. J. Gardner, S. O'Neill, C. Metaxas, “**Understanding the viscoelastic properties of extruded polypropylene wood plastic composites**”, J.of Applied Polymer Science, V89, P.1638-1644, 2003
19. J. I. Kim , S. H. Ryu , Y. W. Chang, “**Mechanical and dynamic mechanical properties of waste rubber powder/HDPE composite**”, J. of Applied Polymer Science, V.77, P. 2595-2602, 2000.

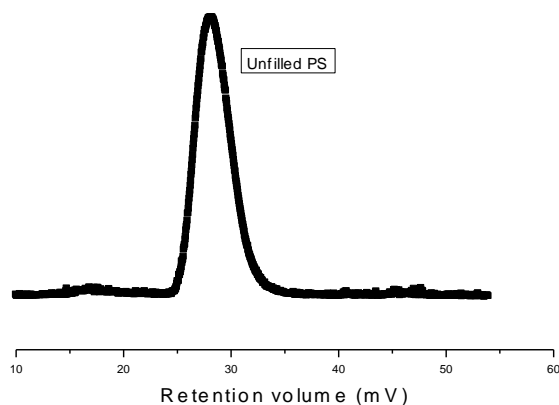


Figure 1: GPC traces for unfilled PS

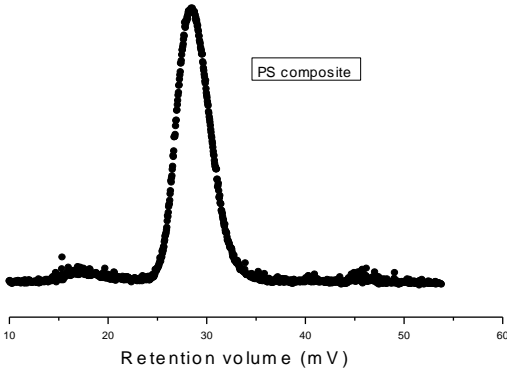


Figure 2: GPC traces for PS composite