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Investigation of the usage of coconut shells in epdm rubber as biodegradable filling material

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Abstract

Ethylene propylene diene monomer rubber (EPDM) is an organic synthetic rubber that we often use in our daily lives. Ethylene propylene diene monomer rubber has entered our daily life as an indispensable material due to its ultraviolet stability, thermal stability and hydrophobic structure. Different filling materials such as accelerating agents, anti-aging agents, cross-linking agents are used to strengthen ethylene propylene diene monomer rubber and increase its usage area. The main purpose of our study is to integrate natural and biodegradable materials into EPDM structure instead of fillers that are used in EPDM and have negative effects on the environment. In this study, Ethylene Propylene Diene Monomer (EPDM) composites with different coconut shell contents were synthesized and the effect of CS filler material on the final composites were investigated. Mechanical properties were characterized in terms of elastic modulus and elongation at break values. Consequently, analyses results showed that the composite of EPDM rubber and coconut shell has good compatibility.

Introduction

Ethylene–propylene–diene monomer rubber (EPDM) rubber is among the most commonly used synthetic rubber types owing to its low cost, high mechanical properties and great filling capacity [1–4]. It is widely used in many different fields such as electronic materials, exterior insulation, sports equipment [5, 6].

Despite all these advantages, rubber materials can remain undissolved in nature for many years. Moreover, it has negative environmental effects due to non-environmentally friendly filling materials such as carbon black it contains [7, 8]. Therefore, in recent years, bio-composite synthesis has been increasing with the use of biodegradable materials as fillers in the rubber industry [9, 10].

Biocomposites are materials consisting of biodegradable polymers (matrix) and biodegradable reinforcing materials. Biodegradable material is substances that can be degraded by living organisms. The fillers used in biocomposites are generally biofibers. During the last 20 years, there has been increasing interest in the development of biocomposite material [11, 12]. One of the most significant properties of biocomposite materials after end-use - being biodegradable, increases the importance of these polymer composites.

Natural plant-derived waste filling materials are low cost and contain shells or unused parts of natural products in waste state. The main advantages of bio-based filler material compared to conventional filling materials are high tensile properties and good biodegradability. Coconut shell as a bio-based filler material is a good candidate in order to obtain the production of environmentally friendly biocomposite materials [13, 14].

In this study, coconut shell wastes (CS) were added to the EPDM matrix in different proportions as a filler and its effect on mechanical properties was investigated. In this way, the usability of CS as a potential biodegradable filler will be analyzed.

Material and Method

Coconut used as a biodegradable filling material in the study was obtained from a local market. In order for the coconut to be used as a filling material in EPDM, the purchased coconuts were washed and cleaned and then kept in a laboratory oven at 50 ˚C. The dried shells were passed through a ball mill and reduced in size and 500 µm coconut shells were obtained as a result of the sieving. Only coconut shells (CS) under 500 microns were used in the study.

The materials used to synthesize the EPDM/CS composite material are presented in Table 1. The chemicals used were used as purchased and were not subjected to any purification process.

Table 1. The recipe of coconut sheell containing EPDM composites

Material	Amount (phr)
EPDM Rubber (Keltan 9650Q)	100
Carbon Black	100
Paraffinic oil	82
ZnO	5
Stearic acid	1.5
Kezadol	2
Peroxide (Perkadox 14–40)	7
Coconut Shell (CS)	0-10-20 (wt, %)

In the preparation of EPDM/CS composite materials, a kneader type mixer was used to mix the chemicals given in Table 1 homogeneously and EPDM paste was prepared. A two-roll mill was used to prepare the EPDM paste as a 2 mm plate. EPDM paste in the form of a 2 mm plate was cross-linked using a heat press at 180 ˚C and under 20 MPa pressure.

The mechanical properties of the synthesized EPDM/CS composite materials were performed according to ASTM D412 standards. The mechanical properties of the specimens (bow-tie shaped) prepared in accordance with ASTM D412 standard were determined with a Shimadzu brand AGS-X model universal tester. In addition, the effect of CS, which is used as a biodegradable filling material, on the crosslink density of the composite material was also examined by swelling analysis. For this purpose, Soxhlet extraction method was applied and hexane was used as solvent. Crosslink densities of composite materials were calculated according to Equation 1 (wi and wf = initial and final weight).

$$Gel\ content\ (\%) = wf/wi * 100 \quad (1)$$

Results and Discussion

The mechanical properties of rubber materials are one of the most significant factors in evaluating the usability of the material. Elongation at break (mm) amount and elastic modulus (MPa) value of EPDM/CS composite materials were examined and the results are given in Figure 1. As can be seen from Figure 1, while the elongation at break of the material with the addition of coconut was similar to that of raw EPDM, a significant increase was observed in the elastic modulus value. It was concluded that CS can be used as a filling material in EPDM in terms of mechanical properties.

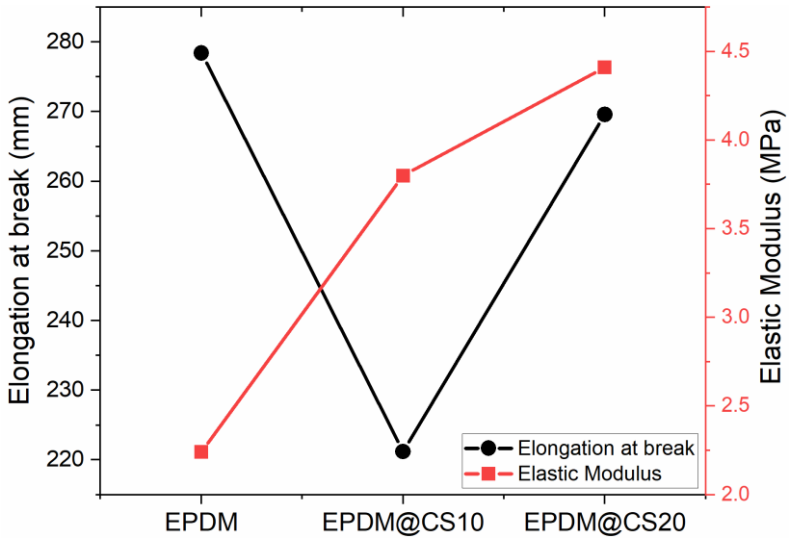

Figure 1. Mechanical properties of EPDM/CS composites

Conclusion

In this study, the usability of coconut shell as a bio-based and biodegradable filling material in EPDM was investigated considering the mechanical properties. For this purpose, CS particles, which were washed and sieved and brought to a particle size below 500 microns, were added to EPDM at different ratios and the mechanical properties of the synthesized EPDM/CS composites were analyzed. With the addition of CS, the elastic modulus values of the material increased significantly, while the elongation at break showed similar values with pure EPDM. Regarding the mechanical properties, it is concluded that CS can be used as an environmentally friendly and biodegradable filling material in EPDM.

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