CHARACTERIZATION OF DIFFERENT ETHYLENE-VINYL-ACETATE COMPOUNDS AFTER TREATMENT WITH A MICROWAVE BEAM

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Abstract - The recycling ethylene vinyl acetate (EVA) is of major interest for the footwear industry in Brazil due to high amounts of rejects obtained in conventional fabrication process like pressing. The direct application of microwaves in combination with uniform heating of the crumb rubber renders the treated crumb rubber more suitable for use in new rubber formulations. As a result, larger particle sizes and/or loading levels of the treated crumb rubber can be used in new rubber mixtures. In this work the mechanical properties of different EVA compounds after treatment in a microwave beam have been characterized

The compounds were prepared from mixtures of EVA microwave (MW) treated crumb rubber with non crosslinked particles. The percentage of microwave treated rubber added to virgin material varied from 10% to 30% by weight. Before the mechanical tests ASTM D-412 these specimens were irradiated with gamma-rays (50kGy) to promote corsslinking. Improvement in the values of tensile strength and elongation at break was observed in the MW irradiated.

Introduction

The recycling of ethylene vinyl acetate (EVA) is of major interest for the footwear industry in Brazil due to high amounts of rejects obtained in conventional fabrication process like pressing. Adhikari et al [1] describe several methods of reclaiming waste rubber like ultrasound and microwaves. The direct application of microwaves in combination with uniform heating of the crumb rubber renders the treated crumb rubber more suitable for use in new rubber formulations by activating its surface [2]. As a result, larger particle sizes and/or loading levels of the treated crumb rubber can be used in new rubber mixtures. The microwave treatment can be controlled so as to target only specific types of chemical bonds or agents by the selection of suitable processing conditions, such as time and temperature, of the microwave bombardment. The aim of this work was the evaluation of the mechanical properties of different mixtures consisting of EVA crumb rubber and non-crosslinked EVA after microwave treatment.

Experimental

The compounds were prepared from mixtures of EVA microwave (mw) treated crumb rubber with non-crosslinked particles. The percentage of microwave treated rubber added to virgin material varied from 10% to 30% by weight. The different mixtures prepared are described in Table 1.

Microwave treatment was performed with frequency of 2450MHz. The mixture of treated particles with the non-crosslinked ones was performed in a conventional press. These specimens were then irradiated with gamma-rays (50kGy) to promote crosslinking. This procedure was done for all different EVA compounds prepared.

The mechanical tests were performed according to ASTM D-412 in an Instron machine (model 4400R).

Results and Discussion

The stress-strain curves for all the compounds prepared are shown in figure 1.

Compound V was used as the reference material for all the other compounds. Its tensile strength value was 10,5 MPa.

From figure 1 it is seen that there is a limit for the incorporation of EVA crumb rubber into new EVA formulations, independently of the compound treatment. The compositions were prepared mixing 10% or 30% of EVA crumb rubber with EVA non-crosslinked particles as described in table I. The tensile strength values dropped from 10,7 MPa for compound A which has 10% of crumb rubber in its composition to 4,82 MPa for compound C which has 30% of crumb rubber in its composition. This same tendency was also found for the compounds B and D.

Compound B with 10% of microwave treated crumb rubber presented a tensile strength of 13,7 MPa while for compound D with 30% of microwave treated crumb rubber this value is 5,54 MPa. The drop in the tensile

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strength value exceeds 50% when the content of crumb in the compound increases from 10% to 30%.
Taking into account the compounds with better mechanical properties, the following features may be stated:

- The highest tensile strength value was obtained for compound B.
- Compounds A and V presented very similar mechanical behaviour as shown in figure 1.

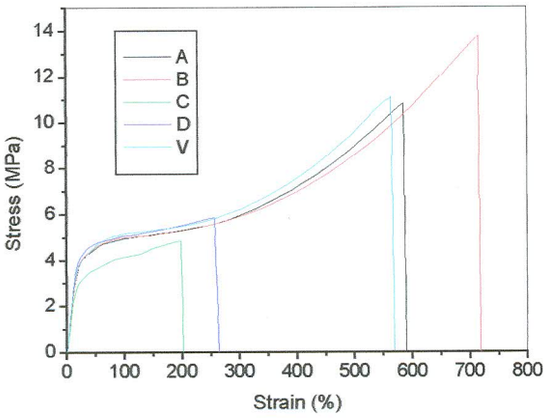
These results indicate that the incorporation of microwave treated crumb rubber particles into a new formulation with non-crosslinked EVA particles improves the mechanical properties of the compound. The explanation for this improvement is not completely understood but may be related to the activated surface of the treated particles, as suggested by Wicks [2]. The incorporation of untreated EVA crumb rubber (compound A) by its turn do not cause any significant beneficial effect on the mechanical properties of the final compound.
As proposed by Wicks [2], the microwave treatment of crumb rubber may activate the surface of the rubber particles, while the internal mechanical properties are not altered. This is due to the fact that the additives incorporated into the original rubber compound are not degraded during the microwave treatment. So, the activated particles may be advantageously incorporated into new non-crosslinked material. Controlling process parameters such as the time of irradiation and the temperature of the compound makes possible to improve the mechanical properties of EVA compounds used in footwear industry.

Table 1 – Different EVA compounds prepared for mechanical tests. The fractions of each product are given in mass percentage.

Compound	*Description
A	Non-crosslinked EVA – 90% EVA crumb rubber – 10% Microwave treatment: NONE
B	**Pre-compound:** EVA crumb rubber – 67% [1]Chemical agent – 33% Microwave treatment: 30 minutes **Final compound:** Non-crosslinked EVA – 90% Pre-compound – 10%
C	Non-crosslinked EVA – 70% EVA crumb rubber – 30% Microwave treatment: NONE
D	**Pre-compound:** the same as for compound C **Final compound:** Non-crosslinked EVA – 70% Pre-compound – 30%
V	Non-crosslinked EVA –100%

1. The chemical agent is used to prevent crosslinking after the microwave treatment. This product is an industrial secret so its structure is not mentioned.

Figure 1 – Stress-strain curves for all the compounds prepared.



Conclusion

The results suggest that the incorporation of 10%wt of microwave treated EVA crumb rubber into a new formulation has beneficial effects on the mechanical properties of the final compound. The improvement of the tensile strength value reaches 30%. From an industrial standpoint this variation is still of minor relevance. However, the microwave treatment used to produce the compounds tested in this work is still under development and the results may be further improved by the selection of suitable process parameters like the time of irradiation and the temperature of the compound during the treatment.

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References

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