Devulcanization of EPDM-Rubber Vulcanizates with Amine Devulcanization Agents

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1 Introduction

The extensive utilization of rubber in various applications, e.g. in the transport area, causes a problem in terms of rubber waste handling. Finding an environmentally-sound solution for this problem is a challenge for the rubber industry nowadays.

The increasingly strict legislation urges the rubber producers and the consumers to consider the possibility of recycling. The EU obliges the automotive industry to recycle at least 95% of the car materials before 2015, and this implies that the rubber-industry cannot escape from recycling of the rubber parts anymore.

Fig. 1: Environmental pollution by accidental burning of tires

2 EPDM-Rubber

EPDM-rubber is the abbreviation of Ethylene-Propylene-Diene-rubber.

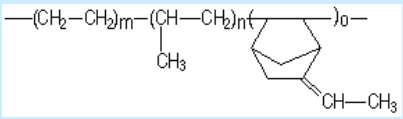

Fig. 2: Molecular structure of EPDM with ENB as diene

Within the range of common rubbers, EPDM is characterized by very good ozone-, heat-, and oxygen resistance. The resistance to weathering and chemicals is outstanding and the resistance to compression set and dynamic fatigue is good. It has good electrical properties and little moisture adsorption. EPDM is suitable for sulfur vulcanization and is not classified as hazardous.

The main uses of EPDM are in automotive applications and in building and construction as profiles, (radiator) hoses, roofing foil and seals.

3 State of the Art: EPDM recycling

Recycling of EPDM-rubber is an interesting topic, regarding the continuous market growth of EPDM. Former work at the University of Twente[1-3] has shown that sulfur-cured EPDM needs far more strenuous conditions to devulcanize than natural rubber. α-H containing aliphatic amines are very effective as devulcanization agents.

Diaryldisulfides, commonly used as devulcanization-aids for NR are to some extent effective in promoting the devulcanization of EPDM. The results are however EPDM-devulcanizates of which the chemical integrity is largely damaged and which is insufficiently active in re-vulcanization.

Batch processes are widely used for reclaiming of rubber, but in the case of EPDM-rubber continuous processes in an extruder[4], microwave[5] and ultrasonic[6] devulcanization are possible as well. All processes result in a reclaim of an inferior quality compared to the virgin material.

4 Project

The aim of the project is developing a continuous process for recycling of EPDM in co-operation with RUG, based on former work at the University of Twente. Investigation at the UT will focus on the material composition of the rubber and in particular on the influence of the:

- type of polymer
- type of filler (carbon black vs. mineral fillers)
- type and amount of extender oil
- type and degree of cross-linking
- devulcanization agent

5 Analytical Part

Characterization of the devulcanizate:
- Mooney viscosity
- Sol-gel analyses
- Cross-link density

Characterization of the cured devulcanizate:
- Tensile properties
- Tear strength
- Compression set
- Dynamic mechanical properties

6 First Step

The first step is the investigation of the influence of the type and degree of cross-linking. EPDM can be vulcanized in different ways resulting in different cross-links:

a) |-S-| b) |-S-S-| c) |S-S-S-S|

Fig. 3: a) mono-, b) di- and c) poly-sulfidic cross-link

1. Conventional vulcanization
- high sulfur/accelerator ratio, resulting in mainly poly-sulfidic cross-links

2. Semi-efficient vulcanization
- medium sulfur/accelerator ratio, resulting in a cross-link of medium length

3. Efficient vulcanization
- low sulfur/accelerator ratio, resulting in short cross-links (mainly mono-sulfidic)

References

1. Duin van M. et al., *Method for Devulcanizing Rubber with an Amine*, 2003,US 2003/0013776 A1:United States.
2. Heideman G., *Amines as Devulcanization Chemicals for EPDM-Rubber.* 1999, University of Twente: Enschede.
3. Verbruggen M.A.L. et al., *Mechanisms Involved in the Recycling of NR and EPDM.* RC&T, 1999. 72(4):p. 731-740.
4. Suzuki Y. et al., *Recycling Technology Using a Twin Screw Reactive Extruder for Vulcanized EPDM Rubber.* Toyota Technical Review, 1998. 48(1): p. 53-57.
5. Novotny D.S. et al, *Microwave Devulcanization of Rubber*.1978.
6. Yun J. & Isayev A.I., *Paper No. 46: Superior Mechanical Properties of Ultrasonically Recycled EPDM Rubber.* Presented at a meeting of the Rubber Division, ACS, Cleveland (October 16-19, 2001).