THE PROPERTIES OF NATURAL RUBBER/CLAY COMPOUNDS

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Abstract

The present work investigates the properties of model rubber compounds, which were prepared with the addition of natural bentonite in function of reinforcement filler. The influence of the used type and quantity of filler was evaluated from results of thermal analysis (DTA, TG, DSC), cure characteristics (M_L, M_H, t_S, t_{90}, R_V) and physical-mechanical properties (tensile strength, modulus 300, tensibility, hardness). The obtained values at the model rubber compounds were compared with the values of standard rubber compound.

Key words

bentonite, filler, rubber compounds, thermal analysis, cure characteristics, physical-mechanical properties

Introduction

Clays and clay minerals such as montmorillonite, saponite, hectorite are widely used as fillers for rubbers and plastics for many years, for saving polymer consumption and reducing the cost [1]. Their addition into polymer matrix leads to significant improvements in physical-mechanical properties. These changes is possible to observe at a very low concentration of the inorganic component in polymers. It is caused by their nanometric dimensions and high aspect ratio. The nanoscopic phase distribution as well as synergism between polymer and the layered silicate result in additional properties, such as flame retardation, enhanced barrier properties and ablation resistance, which are not observed in either component [2, 3].

Experiments

Materials

The natural bentonite, which was used in a function of reinforcement filler is a commercial product of Slovak firm Envigeo, a. s. The particles size of this bentonite product was less than 0,045 mm and the chemical composition (in wt. %) is following: SiO_2: 65.0 , Fe_2O_3: 7.0, CaO: 1.5, MgO: 2.0. A loss on ignition was 7.0 %.

Natural rubber of type SMR-20 was used as the elastomeric matrix and the carbon black of type N660 was selected as a reference filler. The others ingredients and their used amounts are mentioned in Table 1. All agents were used directly without any further purification and modification.

Preparation of model rubber compounds

The model rubber compounds were prepared by the scheme displayed on Fig. 1 and with the prescriptions mentioned in Tab. 1.

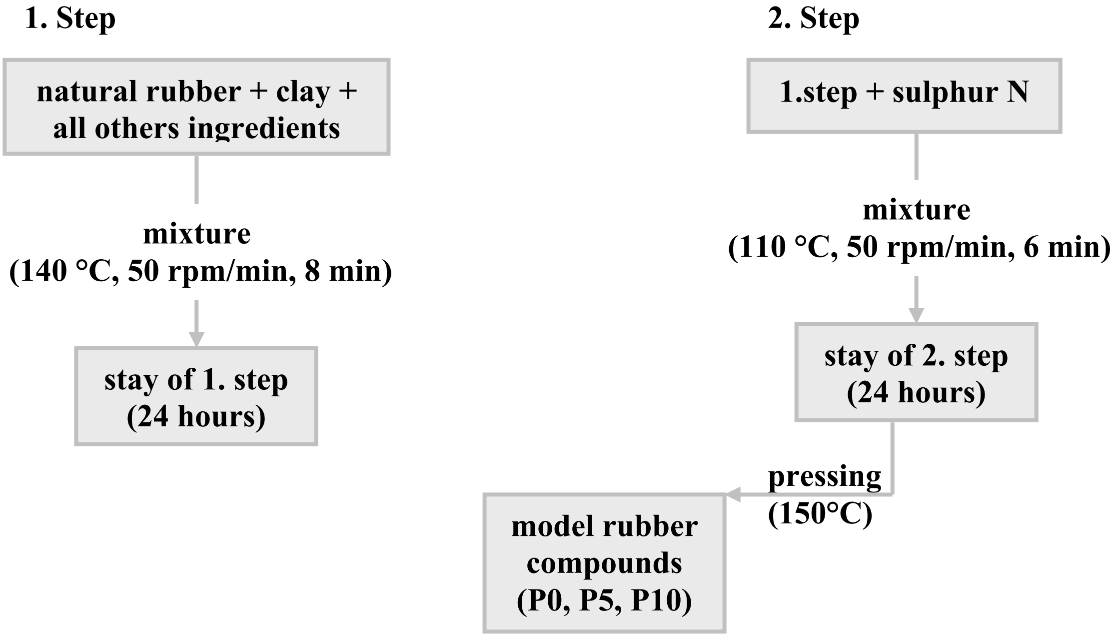

Fig. 1 *The scheme of preparation of the model rubber compounds*

THE PRESCRIPTIONS OF THE MODEL RUBBER COMPOUNDS Table 1

Compounds	**P0 [phr]**	**P5 [phr]**	**P10[phr]**
SMR-20	100		
ZnO	4.6	4.6	4.6
Sulfenax CBS[*]	1.5	1.5	1.5
Carbon black N660	10	5	-
Bentonite	-	5	10
Sulphur N	1.8		

[*] N-cyclohexyl-2-benzothiazolsulfenamid

The samples of the prepared model rubber compounds were submitted to measurements of thermal analysis (DTA, TG and DSC) and to a determination of cure characteristics and physical-mechanical properties.

Methods

Simultaneous DTA and TG measurements were performed on a Derivatograph-MOM, Hungary. The weight of the samples was 150 mg. The samples were heated at a heating rate of 10 °C/min from 25 to 1000 °C in a nitrogen atmosphere.

For study of differential scanning calorimetry (DSC) was used a calorimeter PYRIS Diamond DSC Perkin Elmer. The thermal scan was performed from 30 °C to 250 °C at a heating rate of 10 °C/min under nitrogen atmosphere.

The curing behavior (M_L, M_H, t_s, t_{90}, R_v) was investigated by using of vulcameter Monsanto 100 at the temperature 150 °C during 60 min.

Physical-mechanical properties (tensile strength, modulus at 300 elongation - M_{300}, tensibility) were measured at room temperature by using of instrument Instron at deformation rate 50 mm/min. Hardness was determined at the same temperature by hardness tester IRHD.

Experiment results

Thermal behaviour (DTA, TG, DSC) of the pure natural bentonite and the prepared model rubber compounds are shown in Figs 2, 3, 4 and 5, respectively.

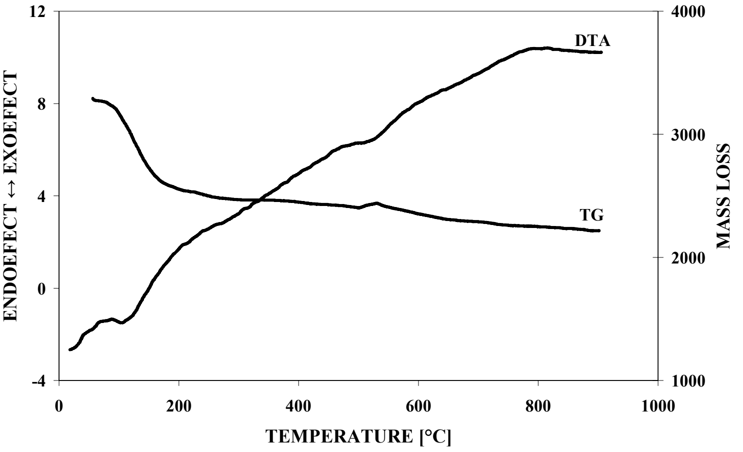

Fig. 2 *DTA and TG of natural bentonite*

The DTA curve of natural bentonite is possible to divide in two areas, the area of dehydration in the thermal interval 20-300 °C and the area of dehydroxylation in the thermal interval 500-1000 °C (Fig. 2). At the area of dehydroxylation occured a decompostion of the structure and started a new high-temperature phases. The physical bounded molecular water got away by heating at temperatures up to 100-120 °C and the water in interlayers space from 120 °C. The OH groups began to release at the temperature around 500 °C and the dehydroxylation finished up to 800 °C [4].

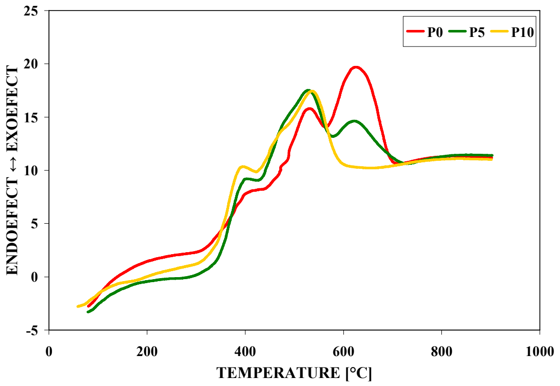

Fig. 3 *DTA of model rubber compounds*

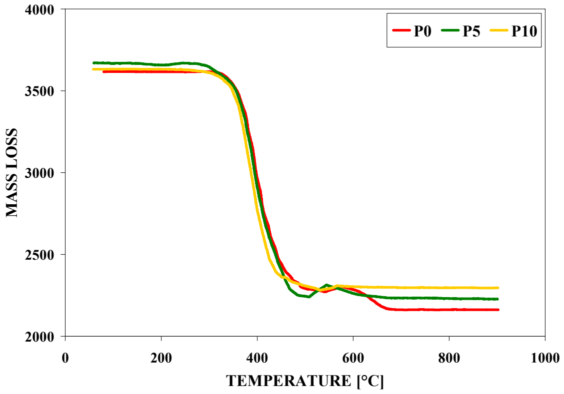

Fig. 4 *TG of model rubber compounds*

At all study model rubber compounds may be see, that the thermal decomposition occured in the thermal interval 300 - 750 °C (Fig. 4). At the model rubber compound P5 are visible three exothermic reactions on DTA curve, what is similar as in the case of the reference rubber compound (P0) (Fig. 3). A total substitution of original filler at the model rubber compound P10 caused changes in the shape of DTA curve - only two exhotermic reactions in the temperature range 320 - 620 °C (Fig. 3)

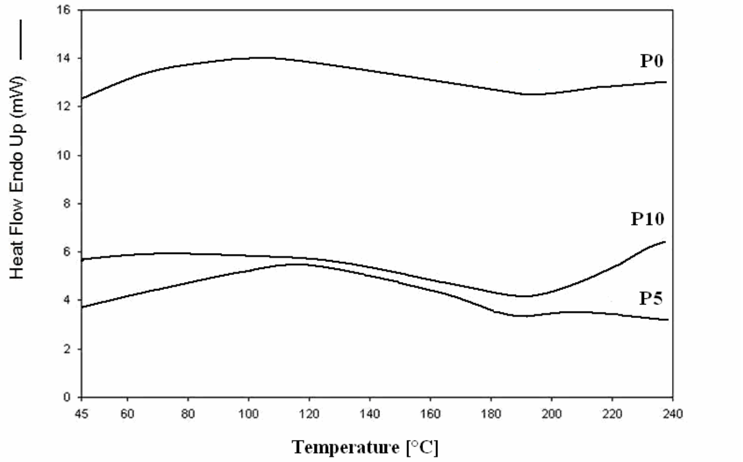

Fig. 5 *DSC of model rubber compounds*

In the DSC thermogram (Fig. 5) of all model rubber compounds was recorded an exothermic reaction in the thermal interval 180 - 200 °C, which characterizes of the cure process [4].

The results of measured cure characteristics (M_L, M_H, t_s, t_{90}, R_V) of prepared model rubber compounds are present in Table 2.

CURE CHARACTERISTICS OF MODEL RUBBER COMPOUNDS Table 2

	Measure	**P0**	**P5**	**P10**
M_L	N.m	5.0	2.7	1.8
M_H	N.m	45.0	43.8	38.5
t_s	min	1.5	1.5	4
t_{90}	min	3.5	4.6	8.2
R_V	min^{-1}	50.00	32.26	23.81

The results of measured physical-mechanical properties of prepared model rubber compounds are present in Table 3.

PHYSICAL-MECHANICAL PROPERTIES OF MODEL RUBBER COMPOUNDS Table 3

Type of test	**Measure**	**P0**	**P5**	**P10**
Tensile strength	MPa	13.17	14.90	20.10
Modulus 300	MPa	5.77	8.29	7.58
Tensibility	%	685	539	796
Hardness	IRHD	47.6	46.2	43.3

The results of measured and evaluated values of cure characteristics and physical-mechanical properties at the model rubber compounds are almost comparable with the values of the reference rubber compound.

Conclusions

The obtained results in present study confirm, that the addition of filler on the base of natural clay, bentonite has a positive effect on the studied properties, because its presence in NR matrix improves them.

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