

Study of the Rheology Properties of a Mixture of Ternary Ethylene-Propylene Rubber with Benzylamine-Modified Phenol-Formaldehyde Oligomer

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Abstract : The presented work showed that the properties of compositions improved based on the modification of ternary ethylene-propylene rubber (SKEPT-60) with chlorinated compounds to ensure adhesive properties, low-speed vulcanization and compatibility with unsaturated functional group rubbers [1-4]. In order to improve the properties of ternary ethylene-propylene rubber, it has been studied the rheological and other properties of the binary system obtained by modifying it in different proportions with benzylamine-modified phenolformaldehyde oligomer (BAFFO) with different proportions of functional groups, and it has been studied that the structure of ternary ethylene-propylene rubber allows the formation of structural changes. At the same time, compositions filled on the basis of SKEPT-60 modified with BAFFO in different proportions were prepared and their properties were studied and it was determined that a number of properties were improved.

Key words: butadiene-nitrile, ternary ethylene-propylene rubbers, phenol formaldehyde oligomer modified with benzylamine, modification, rheology, infrared spectrum, composition, physico-mechanical properties, friction resistance.

1. Introduction

In the conducted research, the rheological properties of the binary mixtures obtained by modifying the ternary ethylene-propylene rubber with BAFFO in different proportions and the sol-gel fraction after being stored in the vulcanization mode and extracted were started. Then composite materials were prepared based on binary mixtures and their properties were studied.

In this study, we presented binary mixtures of ternary ethylene-propylene rubber (SKEPT-60) with benzylamine-modified phenol-formaldehyde oligomer (BAFFO) in different proportions at different temperatures (100, 120, 150, 170 °C) and different loads 11.75; 20.85; Study of rheological properties under the influence of stresses caused by 27.35 and 35.30 kg, extraction of binary mixtures in acetone and tuolol (separately) for 18

hours after keeping binary mixtures in vulcanization mode (1552x35 min), determination of sol-gel fraction, SKEPT Preparation of compositions based on -60 mixtures, etc. such works have been carried out.

2. Objectives

Binary mixtures are prepared by modifying ternary ethylene-propylene rubber with benzylamine-modified phenol-formaldehyde oligomer (BAFFO) in different ratios in order to improve the cohesiveness, bond strength, vulcanization speed, and compatibility of ternary ethylene-propylene rubber with unsaturated rubbers.

Binary mixtures are prepared in the laboratory at a temperature of 40-60°C for 8-10 minutes. The composition of binary mixtures is given in table 1.

Table 1

The composition of a binary mixture

The code of the mix	1	2	3	4	5	6
SKEPT-60	100	100	100	100	100	100
BAFFO	-	2,0	4,0	6,0	8,0	10,0

Total	100	102	104	106	108	110
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To determine whether SKEPT-60 chemically interacts with BAFFO in the binary mixture, the samples were cooled to room temperature after holding the binary mixtures at a temperature of

$153 \pm 2^\circ\text{C}$ for 25 minutes under a pressure of 4.95 Pa. The samples were first extracted in acetone and then in toluene (each separately) for 18 hours to determine the gel fraction (table 2) [5-8].

Table 2

Gel fraction of SKEPT-60/BAFFO binary mixts

Code of binary mixtures	Amount of gel, %
1	-
2	83
3	88
4	91
5	85
6	82

Later, IR spectral analysis of the extracts was performed (picture 1).

Absorption band (3439 cm^{-1}) corresponding to valence vibrations of OH-groups in the IR spectrum of the vulcanized sample. Absorption bands corresponding to valence vibrations of -N-H- bond in binary amines (3154 cm^{-1}), valence of $\text{C}\equiv\text{N}$ bonds in amines (12577 and 1164 cm^{-1}), absorption band corresponding to valence vibrations of CH-bond

($2926\text{-}2852\text{ cm}^{-1}$), aromatic ring Absorption band corresponding to valence vibrations of C-C bond, absorption band corresponding to valence vibrations of benzene ring (1776 cm^{-1}), absorption band corresponding to valence vibrations of benzene ring (1449 cm^{-1}), absorption band corresponding to valence vibrations of CH_2 bond ($1376, 1351\text{ cm}^{-1}$) to valence vibrations of OH-groups corresponding absorption bands (1376 cm^{-1}) are recorded.

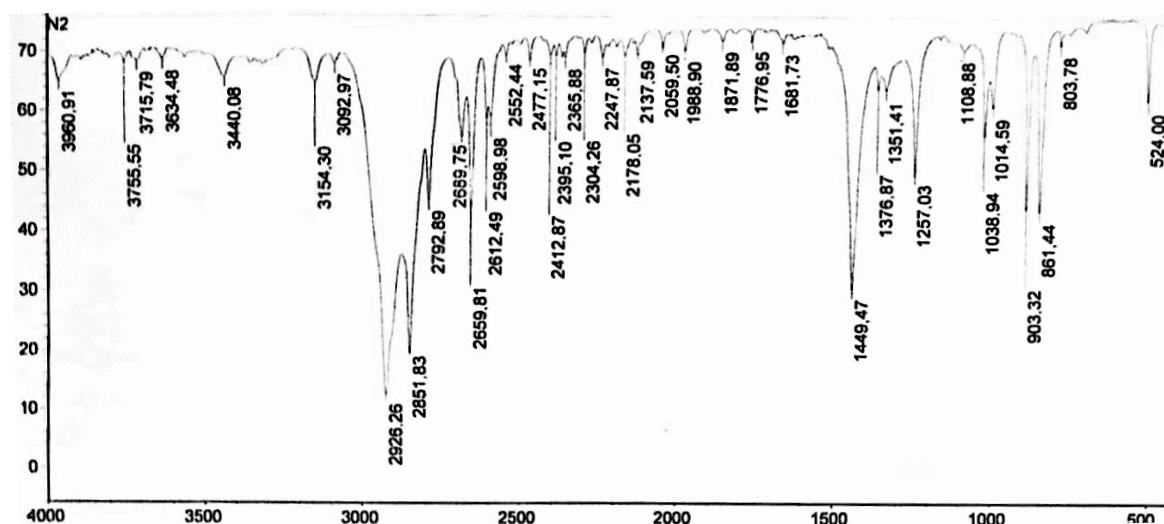


Fig. 1. IR spectral analysis of extracts

Then ternary ethylene-propylene rubber and binary mixtures at different temperatures (100, 120, 150, 170 °C) and different loads 11.75; 20.85; The rheological properties under the influence of stresses caused by 27.35 and 35.30 kg are studied. In the above-mentioned regime, the volume consumption of the alloys of SKEPT-60 and SKEPT-

60/BAFFO binary mixtures depends on the amount of BAFFO in the mixture, the displacement rate (log $\dot{\gamma}$) is log $\dot{\gamma}$ - log τ from the displacement stress (log τ), the effective viscosity (log η_e) is log η_e - log τ from the displacement stress (log τ) and graph curves of effective viscosity depending on the

amount of BAFFO in the mixture were constructed (Fig. 2-9).

Based on the study of rheological properties, the optimal ratio of binary mixtures and the processing mode were determined.

Filled composite mixtures based on SKEPT-60 and SKEPT-60/BAFFO binary mixtures were prepared in a rolling mill at a temperature of 50-60°C for 25 minutes. The prepared composition was vulcanized at a temperature of 153±2°C for 30 minutes.

The physical and mechanical properties of the obtained vulcanizates were studied.

3. Methods

The rheological properties of polymer, polymer-oligomer mixtures are the degree of dispersion, the structure of the dispersed phase, the

segmental mixing layer is formed at the polymer-oligomer boundary. The thickness of the segmental mixing layer depends on the similarity of the polymers. Relatively little work has been done in the field of studying the rheological properties of polymer-oligomer, polymer mixtures. The melting index of ternary ethylene-propylene and binary mixtures was studied at the temperature mentioned above and under the stress caused by a load of 20.85 kg (table 3).

When comparing the flow index of SKEPT-60 and binary mixtures at the given temperatures, it can be seen that the flow index increases monotonically as the amount in the mixture increases at temperatures of 100 and 120°C. This indicates that BAFFO acts as a plasticizer at low temperatures.

Table 3.

Flow indices of SKEPT-60 binary mixtures, q/10 min

Code of mix Temperature	1	2	3	4	5	6
100°C	0,0067	0,0084	0,0143	0,0289	0,0553	0,1003
120°C	0,0048	0,0591	0,1036	0,1320	0,4606	0,9330
150°C	0,1094	0,1514	0,1614	0,1558	0,1718	0,1428
170°C	0,2024	0,2490	0,2486	0,2500	0,3622	0,3004

When comparing the flow index of SKEPT-60 and binary mixtures at the given temperatures, it can be seen that the flow index increases monotonically as the amount in the mixture increases at temperatures of 100 and 120°C. This indicates that BAFFO acts as a plasticizer at low temperatures.

At temperatures of 150 and 170°C, the amount of BAAFO in the mixture (4-6) k.h. when the flow index remains almost constant, in the subsequent increase of BAFFO (6-8) k.h. while the flow index increases and decreases instantaneously.

This feature of flow index suggests that BAFFO (4-6) k.h. in the mixture at temperatures of 150-170°C. amount corresponds to the degree of unsaturation of ternary ethylene-propylene rubber and interacts with the macromolecule of rubber, when the amount of BAFFO exceeds 6.0 k.h., the flow index of the mixture increases sharply, that is, the excess part plays the role of a plasticizer. The amount of BAFFO in the mixture (8-10) k.h. when the flow index decreases sharply, that is, the

amount of flow decreases as structuring takes place.

11.75 of alloys of SKEPT-60/BAFFO binary mixtures at temperatures (100, 120, 150, 170 °C) and various loads; 20.85; We construct graphs of dependence of volume consumption on the amount of BAFFO in the mixture under the influence of stresses created by 27.35 and 35.30 kg (Fig. s 2-5).

SKEPT-60 rubber does not flow under the influence of the first load at the temperature of 100°C, the amount of BAFFO in the binary mixture is 10 k.h. flows when Under the influence of other loads, the volume consumption of SKEPT-60 and binary mixtures increases as the amount of BAFFO in the mixture increases. That is, BAFFO acts as an emollient in the mixture. Volume consumption of binary mixtures in the temperature range of 120-150°C, the amount of BAFFO in the mixture (2-6) k.h. is approximately constant under the stress caused by each load in the interval, the amount of BAFFO (8-10) k.h. In the interval, the volume consumption increases sharply. The mentioned

feature suggests that BAFFO (2-6) k.h. in the mixture. the amount of which corresponds to the amount of the double layer of triple ethylene-propylene rubber enters into a chemical relationship, creating a structural change in its structure, its viscosity increases and its volume remains constant. BAFFO's (8-10) k.h. since the quantity is more, either the softener in the mixture or the structuring at the temperature of 150-170°C

decreases the intensity of the volume consumption of the mixture. Then, we studied the rheological properties of SKEPT-60 and SKEPT-60/BAFFO binary mixtures at the above-mentioned temperatures and under the stress caused by loads, and the dependence of the displacement rate ($\log \dot{\gamma}$) on the displacement stress ($\log \tau$) and $\log \dot{\gamma}$ - $\log \tau$ graphical curves is constructed (Fig. 2-9).

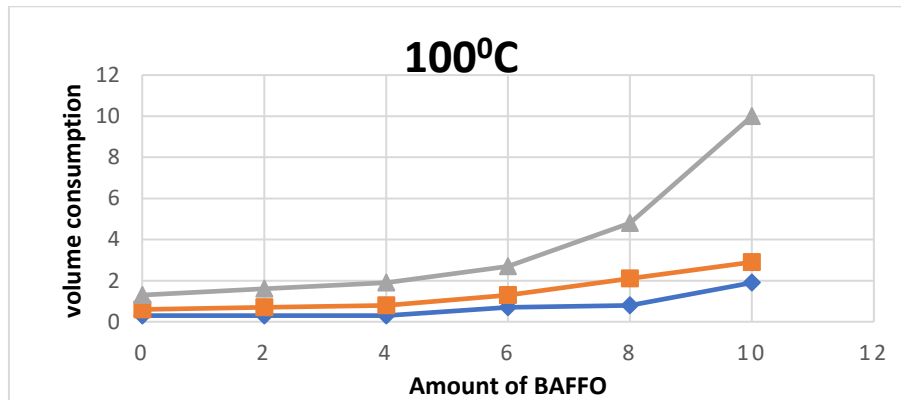


Fig. 2. Dependence of volume consumption on the amount of BAFFO in the binary mixture (100°C)

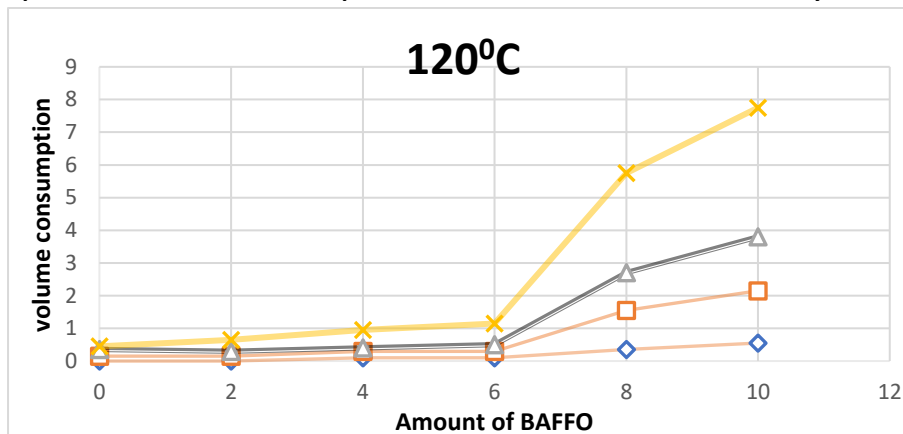


Fig. 3. Dependence of volume consumption on the amount of BAFFO in the binary mixture (120°C)

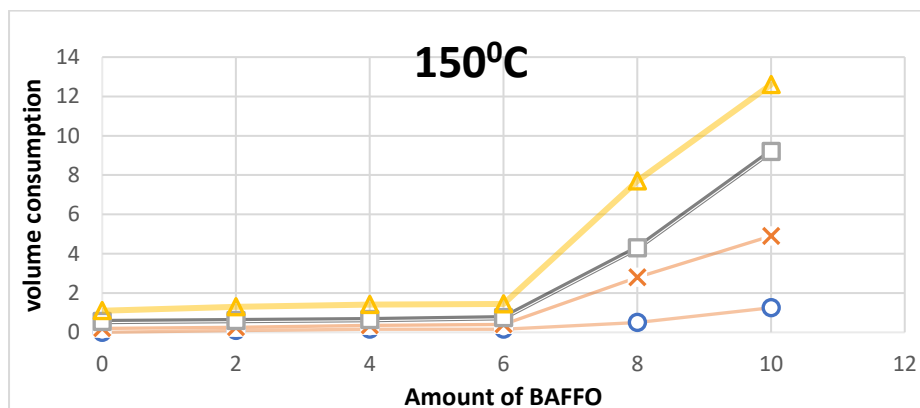


Fig. 4. Dependence of volume consumption on the amount of BAFFO in the binary mixture (150°C)

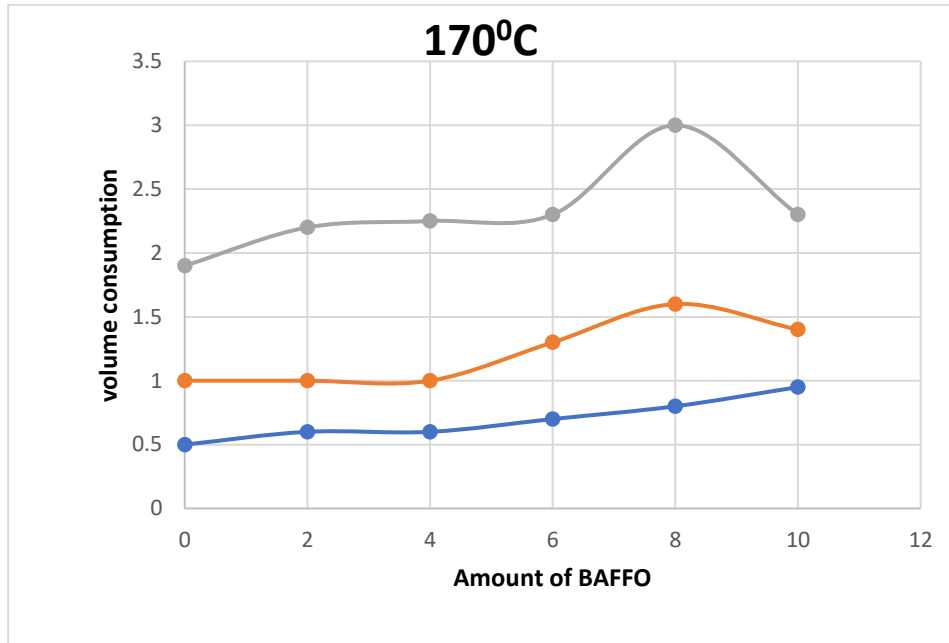


Fig. 5. Dependence of volume consumption on the amount of BAFFO in the binary mixture (170°C)

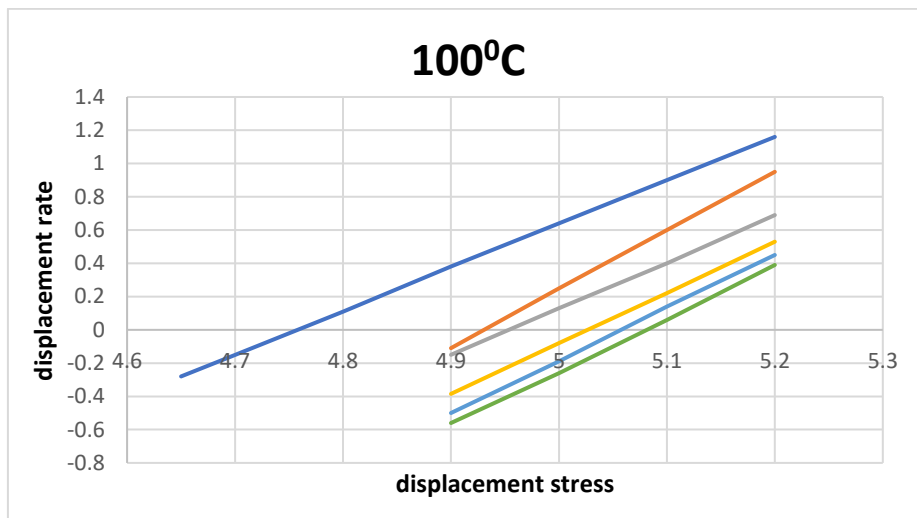


Fig. 6. Dependence of displacement rate on displacement stress (100°C)

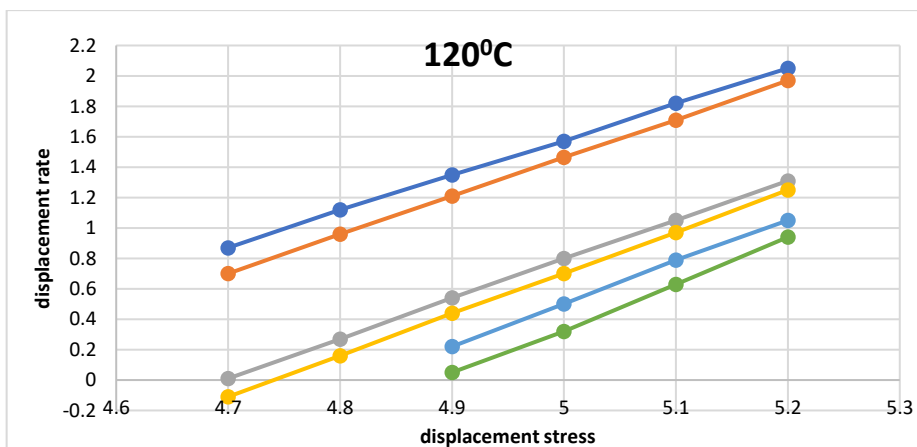


Fig. 7. Dependence of displacement rate on displacement stress (120°C)

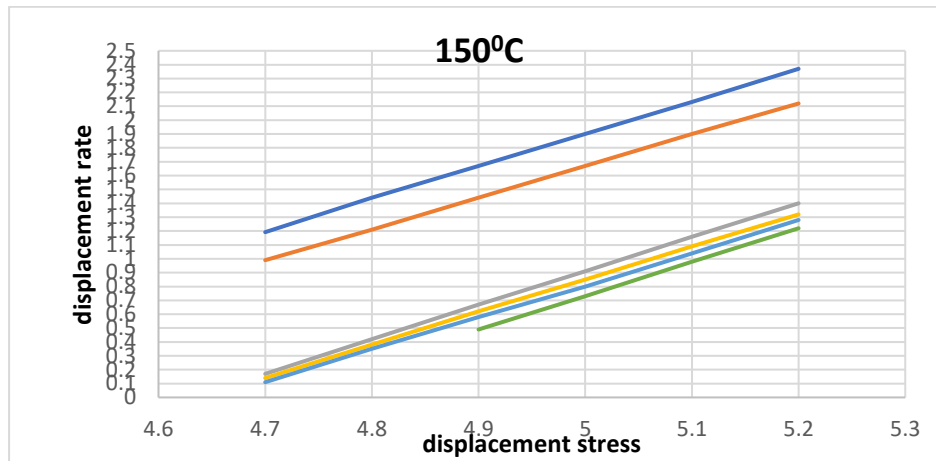


Fig. 8. Dependence of displacement rate on displacement stress (150°C)

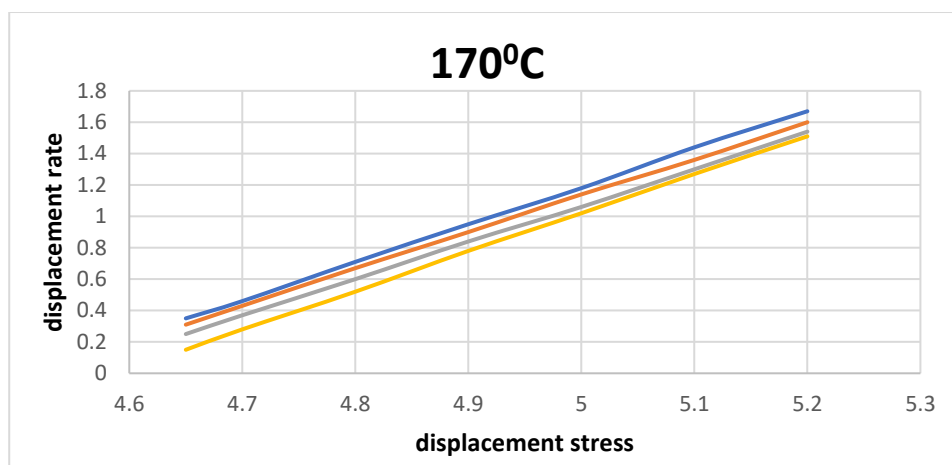


Fig. 9. Dependence of displacement rate on displacement stress (170°C)

Analyzing the character of the constructed graph curves, it can be determined that the amount of BAFFO in the binary mixture at temperatures of 100-120°C is (2-6) k.h. when, as a rule, the flow rate of melt increases due to SKEPT-60, but the amount of BAFFO in the mixture (8-10) k.h. and when there is a large jump, the flow rate of alloys increases. The fact that the flow rate character is so different indicates that the amount of BAFFO in the mixture (2-6) k.h. is well dispersed in the polymer phase, the excess (8-10) k.h. and increases the flow rate by settling in the polymer phase as a softener. The amount of BAFFO in the binary mixture at 150°C is (2-6) k.h. when the flow rate of binary mixtures is close to each other, they are very close to the flow rate of SKEPT-60, the amount of BAFFO (8-10) k.h. and when there is a sharp flow rate, it approaches SKEPT-60 faster. This difference in the flow characteristics of the alloys shows that in the mixture (2-6) k.h. The

amount of BAFFO is in mutual chemical relationship according to the amount of double bonds in triple ethylene-propylene rubber, the excess part plays the role of emollient, and at 170°C temperature, the excess part is structured and reduces the flow rate [8-10].

Based on the study of the rheological properties of SKEPT-60/BAFFO binary mixtures, it was determined that the amount of BAFFO in the mixture (2-6) k.h. when it means that it interacts with ternary ethylene-propylene rubber, the flow indicators are close to each other. In order to determine the interaction of BAFFO with ternary ethylene-propylene rubber, it is of great interest to prepare composite materials filled on the basis of ternary ethylene-propylene rubber modified with BAFFO and study their physical and mechanical properties. First, we mechanically modify the ternary ethylene-propylene rubber with different

proportions of BAFFO in a laboratory roller at a temperature of 40-60°C for 4-6 minutes (table 4).

Table 4
Composition of binary mixtures

Code of mix Temperature	1	2	3	4	5	6
SKEPT-60	100	100	100	100	100	100
BAFFO	-	2	4	6	8	10
Total	100	102	104	106	108	110

Finally, by adding other components, a filled composite material is prepared. The prepared composite material was vulcanized at a temperature of 153±2°C for 30 minutes, and the physical and mechanical properties of the vulcanizates obtained were studied (table).

Table 5
Physical and mechanical properties of compositions obtained on the basis of SKEPT-60/BAFFO

The code of the mixture The pointers	1	2	3	4	5	6
Breaking strength limit, MPa	20,2	20,8	21,6	22,8	21,3	20.5
Conditional stress at 100% elongation, MPa	3,5	3,7	3,8	3,93	3,75	3,8
Conditional stress at 300% elongation, MPa	13,4	13,9	14,3	14,9	14,3	14,0
Relative elongation, %	375	375	380	380	385	390
Residual deformation	14,2	13,9	14,2	14,9	15.2	16,0
Hardness on the TM-2 device, s.v.	69,5	69	68.2	67,8	67,3	66,9
Metal bond strength	1,49	1,74	1,85	2,06	2,0	1,96
Rebound elasticity, %	39,6	40,0	40,5	39,5	38,6	37,9
Abrasion coefficients after 38 h storage at 393K						
f_p	0,78	0,79	0,82	0,84	0,82	0,83
f_E	0,42	0,42	0,41	0,42	0,42	0,41
Fatigue resistance in repeated deformation (V=250 cycles/min, L=200%, T=294 K cycles)	1.082	1,127	1,236	1,378	1,399	1,401
Tensile strength, kN/m	35,4	36,3	37,9	39,5	38,4	37,8

Analyzing the properties of the obtained vulcanizates, it can be seen that the ternary ethylene-propylene rubber (2-6) k.h. The physical and mechanical properties of the compositions obtained on the basis of modification with BAFFO have improved compared to the composition based on SKEPT-60.

For example, breaking strength is 20.2 MPa vs. 22.8 MPa, metal contact strength is 1.49 MPa vs. 20.6 MPa, tear resistance is 35.4 kN/m, temperature wear coefficients properties can be mentioned.

4. Results

Binary blocks were prepared by mechanical modification of ternary ethylene-propylene rubber with different proportions of BAFFO at a temperature of 40-60°C for 8-10 minutes.

After keeping SKEPT-60/BAFFO binary mixtures in the vulcanization mode at a temperature of 153±2°C for 25 minutes under a pressure of 4.95 Pa, first in acetone and then in toluene (in each separately) for 18 hours, the gel fraction was determined.

IR-spectra of the extracted extracts were taken and analyzed. It is likely that the OH groups in the

phenol-type structural fragment interacted with the double bonds contained in the triple ethylene-propylene rubber and formed a chemical bond.

The rheological parameters of SKEPT-60 and SKEPT-60/BAFFO binary mixtures were determined by the capillary viscometry method in the IIRT-4 device.

Graphical curves of $\log y - \log t$ dependence of displacement rate ($\log y$) and displacement stress ($\log t$) of the volume consumption of the alloys of SKEPT-60 and SKEPT-60/BAFFO binary mixtures on the amount of BAFFO were constructed.

Filled compositions based on SKEPT-60 and SKEPT-60/BAFFO binary mixtures were prepared and properties of their vulcanizates were studied. It has been shown that the physical-mechanical indicators of the composition based on the SKEPT/BAFFO-100/4-6 ratio have improved compared to the composition based on SKEPT-60.

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