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Propertıes of NBR/modıfıed EPDM rubber composıtıons

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This study investigates the functional modification of ternary ethylene-propylene rubber (EPDM) with benzamine phenol formaldehyde (BPFO) to enhance its properties and compatibility with butadiene-nitrile rubber (NBR). Samples with varying compositions were prepared, and their rheological properties were analyzed to identify optimal blends. This study's novelty stems from its simultaneous improvement of EPDM's compatibility with NBR, mechanical strength, thermal resistance, tear strength, and metal adhesion, along with the determination of optimal blend ratios for industrial applications.

The addition of 4-6 parts by weight (p.w.) of BPFO to SKEPT-60 led to a 12% increase in fracture strength and up to a 30% improvement in metal adhesion. This range was found to be optimal. The introduction of functional groups (–OH, $–NH_2$, $–CH_2–$) enables cross-linking, increases stiffness and mechanical strength, and enhances thermal stability. Furthermore, BPFO improves the compatibility between NBR and EPDM, reducing swelling in aggressive environments due to its aromatic structure.

The resulting modified rubber compositions have numerous industrial applications, including automotive components, fuel and oil pipelines, compressor seals, and machinery parts in petrochemical, aviation, construction, and household industries. They are especially suitable for high-performance sealing and insulating applications in harsh conditions, offering improved chemical resistance, durability, and long-term reliability.

Keywords: butadiene-nitrile rubber, ternary ethylene-propylene, temperature, compositions, functional group.

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Introduction

Polymer composite materials are widely used in modern industries because they offer a unique combination of mechanical strength, thermal stability, and chemical resistance [1]. Among elastomeric materials, nitrile butadiene rubber (NBR) and ethylene–propylene–diene monomer (EPDM) are of particular interest due to their complementary properties. NBR has excellent oil and fuel resistance due to its high acrylonitrile content, while EPDM is known for its outstanding ozone and thermal resistance due to its saturated backbone structure [2]. However, both elastomers also have certain limitations: NBR has relatively poor weathering resistance, whereas EPDM has low adhesion and insufficient compatibility with other unsaturated rubbers [3].

To overcome these limitations, researchers have explored various approaches, including chemical modification, compatibilization, and the incorporation of co-agents or reinforcing fillers [4]. Recent studies have shown that adding organic acids, functionalized polymers, and nanofillers can significantly improve crosslink density, mechanical properties, and long-term durability of elastomer blends [5]. For example, maleic anhydride-grafted polymers and phenol-formaldehyde resins have been used to enhance adhesion and filler–rubber interactions, while nanocarbon additives like graphene or CNTs have demonstrated reinforcement efficiency at low loadings [6].

Despite these advances, developing NBR/EPDM composites with balanced performance remains a relevant research challenge. In particular, the influence of adipic acid and benzamine phenol–formaldehyde oligomers (BPFO) on the vulcanization behavior, adhesion, and dielectric properties of such blends has not been systematically investigated [7]. These compounds are expected to act as co-agents and compatibilizers, improving the interaction between the polymer phases and strengthening the three-dimensional network [8-9].

This research focuses on preparing and characterizing composite materials composed of NBR and EPDM elastomers, modified with BPFO under various formulations. The main goal is to determine how this modifier affects rheological behavior, crosslink density, and physicomechanical properties. The originality of this work stems from applying BPFO to NBR/EPDM systems, offering new insights into optimizing blend formulations to enhance wear resistance, adhesion, and dielectric stability.

I. Experimental part

Modification of Ternary Ethylene-Propylene Rubber (SKEPT-60) with BPFO

The objective of this study is to enhance the industrial applicability of ternary ethylene-propylene rubber (SKEPT-60) by chemically modifying it with functional compounds. Benzoamine-modified phenol-formaldehyde oligomer (BPFO) was chosen to modify SKEPT-60, enabling its use in butadiene-nitrile rubber (NBR) blends.

Binary mixtures of SKEPT-60 and BPFO were prepared in a laboratory furnace at 50–60 °C for 4–5 minutes, with varying rubber-to-BPFO ratios (Table 1). The BPFO proportions are given in parts by weight relative to the polymer matrix. The rheological properties of these mixtures were then studied using an IIRT-5 capillary viscometer (Fig. 1). Measurements were performed three times to ensure reproducibility.

Table 1

Composition of the SKEPT-60/ BPFO binary mixture

№	Components	Samples					
		1	2	3	4	6	6
1	SKEPT-60	100	98	96	94	92	88
2	BPFO	-	2	4	6	8	12

The binary mixtures are then characterized by studying their rheological properties in an IIRT-5 capillary viscometer.

Chemical modification is widely used to improve specific properties of polymers, such as resistance to oil and fuel, adhesion to surfaces, co-vulcanization, and compatibility with other polymers. For comparison, previous studies have reported the modification of isobutylene-isoprene and ethylene-propylene rubbers with acrylamide (AA) and methacrylate amine (MAT) in solution using initiators. These modifications, performed at 100 °C and 1.5 wt.% concentration, improved the physicomechanical properties of the resulting compositions [10].

Fig.1. IIRT-5 capillary viscometer.

Graft copolymerization of ethylene-propylene copolymers with methacrylates using complex radical initiators has also been demonstrated. Photochemical modifications utilize functional groups within polymer macromolecules that can absorb light, producing high-purity polymers for industrial and biomedical applications. Ionic modification mechanisms allow for controlled chain growth and side-chain length, preserving macromolecular activity over extended periods [11-12].

During mechanical-chemical processing, polymer macromolecules undergo deformation, thermal expansion, radical formation, and polymerization. Factors such as electron flow from macromolecular displacement, friction-induced heating, and applied mechanical forces affect these transformations [13-14].

In this study, SKEPT-60 was modified with BPFO in various proportions (p.w.) in a laboratory flask at 50–60 °C for 4–5 minutes to prepare binary mixtures. The mixtures were then vulcanized at 153 ± 2°C for 25 minutes under a pressure of 110 atm. After vulcanization, the binary mixtures were extracted with acetone, and FTIR spectra were recorded to investigate structural transformations.

The melt index of the binary mixtures was determined under G2 load (20.85 kg). The flow index is the mass of the polymer (g) that flows through the capillary in 10 minutes under a specified load and temperature. Shear rate ($\dot{\gamma}$) and shear stress (τ) were calculated from capillary flow data, and the flow behavior exponent (n) was obtained as the tangent of the slope α in the log–log plot.

$$n = tan\alpha = \frac{\log\tau}{\log\dot{\gamma}}$$

where:

$\dot{\gamma}$ – shear rate (s^{-1})

τ – shear stress (Pa)

α – slope angle of the log $\dot{\gamma}$–log τ plot

The flow index is studied in relation to the pressure created by the load (in kg). The indicators from this study are presented in Table 2.

Table 2.

Melting Index of Alloys under G2 Load

Temperature	Melt index g/ 10 minutes					
	samples					
	1	2	3	4	5	6
100^0C	0.0068	0.0090	0.0143	0.0289	0.0553	0.1004
120^0C	0.0482	0.0589	0.1038	0.1319	0.4607	0.9337
150^0C	0.1094	0.1515	0.1639	0.1628	0.5769	0.1428
170^0C	0.2026	0.2490	0.2486	0.2902	0.3622	0.3006

In the article, we examine the rheological properties of SKEPT-60/BPFO binary mixtures. We calculated the volume flow rate of the alloy by measuring the time it took for the binary mixture to flow a certain distance ($S = 0.02$ cm) along the capillary length due to pressure created by different temperatures (100, 120, 150, and 170°C) and loads (G1, G2, G3, and G4). Our study found that at 100°C, the volume flow rate increased under the influence of all stresses. This suggests that BPFO acts as a softener in the binary mixture. At 120°C, the volume flow rate of the binary mixture alloys increased due to the stress created by the G1 and G2 loads, indicating that BPFO acts as a plasticizer. Under the tension created by! the G3 and G4 loads, the flow in samples 1 and 2 increased, while in samples 3 and 4, the flow volume stabilized, and in samples 5 and 6, the volume flow increased again. This shows that BPFO interacts with SKEPT-60 under the pressure created by the G3 and G4 loads, resulting in a constant volume flow regardless of the amount of BPFO. Specifically, in the SKEPT-60/BPFO-96-94/4-6 ratios, the volume flow is constant when the amount of BPFO in the binary mixture is 2, 8, 10, and 12 p.w., and it increases when the amount of BPFO is 4-6 p.w., indicating that it acts as a plasticizer [15-17].

At 150°C, the volume flow of the alloy in the SKEPT-60/BPFO-96-94/4-6 ratio remained constant under the pressure created by all loads (G1, G2, G3, and G4). In contrast, the volume flow of alloys with other ratios increased. This suggests that when the amount of BPFO in the binary mixture is 4-6 p.w., it allows for complete mixing and bonding with SKEPT [18-20].

At 170°C, the volume flow of SKEPT-60/BPFO binary mixtures increased rapidly under the pressure created by the G1 load, but as the stresses created by the G2, G3, and G4 loads increased, the volume flow rate decreased rapidly. This can be explained by the fact that as the pressure increases, both destruction and construction (combination) occur [21-25].

After finding the tangent of the angle formed by the velocity line ($tg\alpha = n = (\log \dot{\gamma})/(\log\tau)$) from the dependence curves between the average displacement velocity and deformation stresses of the SKEPT-60/BPFO binary alloy alloys at temperatures of 100, 120, 150, and 170°C, we constructed the $\log \dot{\gamma}$-$\log\tau$ graphical curves after taking the known alloy profiles. We constructed and analyzed the $\log \dot{\gamma}$-$\log\tau$ graphical curves of the binary alloy alloys at a temperature of 100°C. As the value of the shear stress increases, the shear rate of binary alloy alloys increases. The exception is that the shear rate is not observed in binary alloy alloys due to the effect of the τ1-stress. As shown in the graph (Fig. 2), after finding ($tg\alpha = n = (\log \dot{\gamma})/(\log\tau)$), we constructed the $\log \dot{\gamma}$-$\log\tau$ graphical curves after the known ratios of the alloy were taken. We constructed and analyzed the $\log \dot{\gamma}$-$\log\tau$ graphical curves of the alloys of binary alloys at a temperature of 100°C. As shown in the graph (Fig. 2), the shear rate of binary alloy alloys increases as the value of the shear stress increases. The exception is that the shear rate is not observed in binary alloy alloys due to the effect of the τ1-stress.

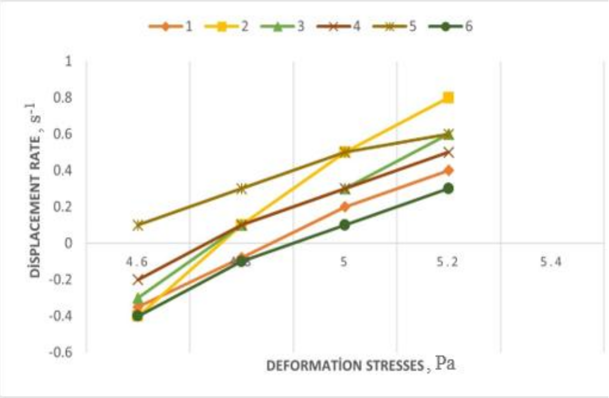

Fig. 2. Dependence curves between the average displacement rate ($\dot{\gamma}$,S^{-1}) and deformation stresses (τ, Pa) of SKEPT-60/BPFO binary alloy components at 100^0C.

At a temperature of 120 °C, the $\log \dot{\gamma}$–$\log \tau$ curves of the SKEPT-60/BPFO binary mixture alloys were constructed and analyzed (Fig. 3). As shown in Fig. 3, the curves for samples 3 and 4 nearly coincide due to the influence of the stresses τ_3 and τ_4. The mixture composition in this case corresponds to SKEPT-60/BPFO-96–94/4–6. When the BPFO concentration in the mixture is between 4–6 p.w., a homogeneous binary system with SKEPT forms. However, when the BPFO content increases to 8–12 p.w., the alloy's displacement rate exhibits a sharp increase. This observation indicates that above 6 p.w. BPFO, the additive plays a distinct softening role in the alloy matrix.

At a temperature of 150 °C, the $\log \dot{\gamma}$–$\log \tau$ curves of SKEPT-60/BPFO binary mixtures were analyzed under different deformation stresses (Fig. 4). As illustrated, when the BPFO amount in the binary mixture is 2 p.w. (sample 1), it primarily acts as a plasticizer, and the alloy's displacement rate increases at a slower pace compared to pure SKEPT. At intermediate compositions, specifically 4–6 p.w. BPFO (samples 3 and 4), the velocity curves of the alloys nearly overlap despite the difference in concentration. This behavior suggests that at this range, BPFO fully interacts with SKEPT-60, forming a uniform, cooperative system. When BPFO increases to 8–12 p.w., the alloy's displacement rate increases significantly,

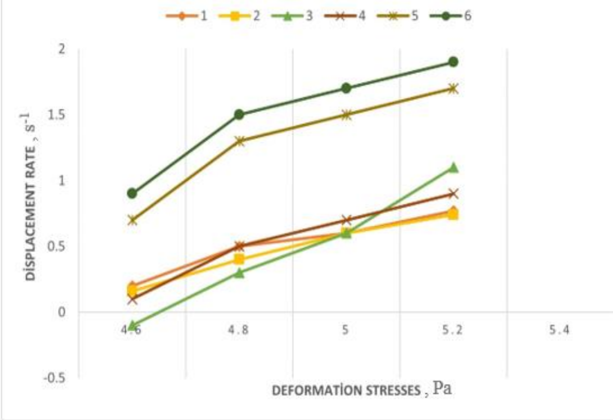

Fig. 3. Dependence curves between the average displacement rate and deformation stresses of SKEPT-60/BPFO binary alloy components at 120^{0}C.

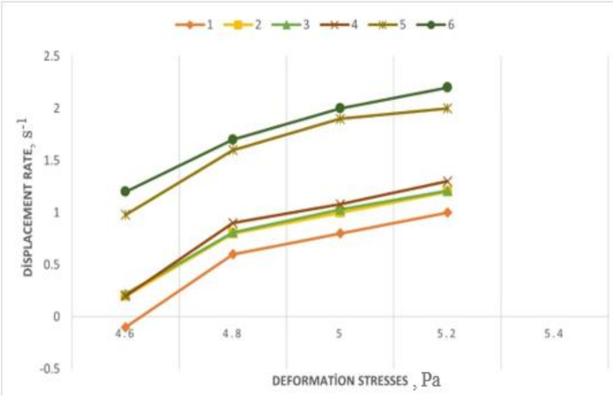

Fig. 4. Dependence curves between the average displacement rate and deformation stresses of SKEPT-60/BPFO binary alloy components at 150^{0}C.

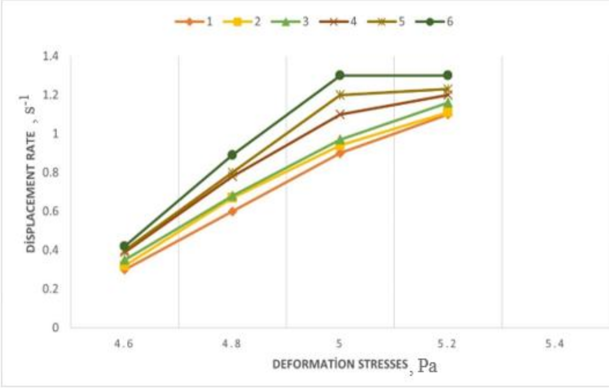

Fig. 5. Dependence curves between the average displacement rate and deformation stresses of SKEPT-60/BPFO binary alloy components at 170^{0}C.

indicating that the excess BPFO beyond 6 p.w. no longer contributes to structural integration but rather functions as an external plasticizer. Consequently, it can be inferred that the optimal BPFO content for the binary mixture lies within the range of 4–6 p.w., ensuring both homogeneity and stability of the alloy.

At a temperature of 170°C, the log $\dot{\gamma}$–log τ curves of the alloys of the SKEPT-60/BPFO binary mixtures were also examined (Fig. 5). As evident from the figure, the shear rates of all binary mixture samples converge and become comparable to the melting rate of pure SKEPT-60. This behavior can be explained by the fact that after approximately 4–6 p.w. BPFO has interacted and combined with SKEPT, the surplus BPFO macromolecules tend to self-associate. Such molecular aggregation enhances the overall viscosity of the system, which, in turn, reduces the alloy's displacement rate. These findings highlight the dual role of BPFO: initially as a structural co-component enhancing homogeneity, and subsequently as a plasticizer beyond the threshold concentration, influencing both viscoelastic and flow characteristics of the binary mixture [26–29].

SEM (fig 6.) was used to examine the microstructural features of NBR/EPDM blends with different amounts of BPFO plasticizer [30]. The goal was to see how the concentration of BPFO affects the phase morphology, homogeneity, and structural integrity of the blends.Analysis and Interpretation:

2 p.w. – Low BPFO (Initial plasticization stage):

The micrograph shows a porous and fiber-like morphology.

At this stage, BPFO mainly acts as a plasticizer, reducing friction between molecules and increasing chain mobility. The presence of voids and irregularities indicates that the polymer blend is not fully homogenized.

2. 4–6 p.w.– Moderate BPFO (Homogenization stage):

The surface morphology appears smooth and homogeneous.

This concentration provides the right amount of plasticization, promoting better adhesion between phases and phase compatibility. The homogeneous morphology is linked to improved mechanical strength and stability of the material.

8–12 p.w.– High BPFO (Over-plasticization stage):

The microstructure becomes porous and irregular again.Too much plasticizer leads to phase separation and structural defects within the polymer matrix. This over-plasticization weakens the blend, reducing its mechanical performance and long-term stability.

The SEM analysis shows that the morphological

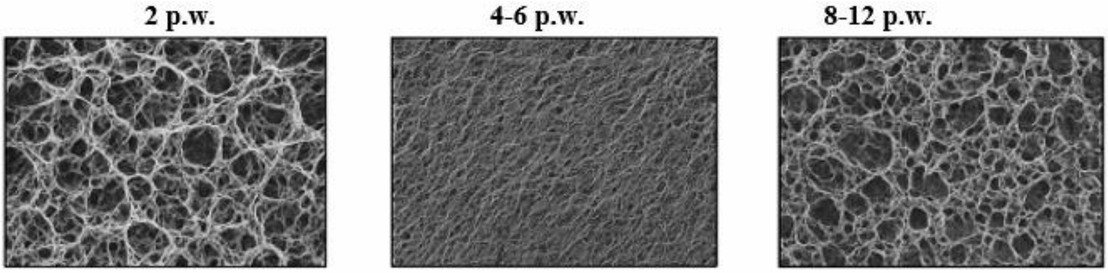
2 p.w. 4-6 p.w. 8-12 p.w.

Fig. 6. Scanning Electron Microscopy (SEM) Analysis.

stability of NBR/EPDM blends highly depends on the concentration of BPFO.

At low content (2 p.w.), the system is inhomogeneous with voids and irregularities.At optimal content (4–6 p.w.), the blends achieve a uniform and homogeneous morphology, which correlates with superior mechanical properties. At high content (8–12 p.w.), over-plasticization causes phase separation and porosity, resulting in a decline in performance.Thus, the optimal concentration range of BPFO is 4–6 p.w., ensuring both morphological homogeneity and mechanical durability.

II. Result

This study reveals that modifying SKEPT-60 with BPFO significantly enhances its physical and mechanical properties, particularly in blends with NBR. Consistent results from rheological measurements, melt index analysis, and morphological (SEM) characterization indicate that the optimal BPFO concentration falls within the 4-6 parts by weight range .

At this concentration, BPFO introduces functional groups (-OH, -NH_2, -CH_2-) into the polymer matrix, which facilitates crosslinking, increases network density, and improves compatibility between EPDM and NBR phases. Consequently, the modified rubber exhibits a 12% increase in fracture strength, up to a 30% improvement in metal adhesion, and notable enhancements in thermal stability and wear resistance. SEM analysis corroborates these findings, revealing smooth and homogeneous morphologies at 4-6 p.w., in contrast to the porous and irregular microstructures observed at lower (2 p.w.) or higher (8-12 p.w.) loadings.

The optimized SKN-40/SKEPT-60/BPFO (90/9.6-9.4/0.4-0.6) composition offers a promising route for producing oil and fuel-resistant, durable rubber products, including automotive components, compressor seals, petrochemical gaskets, pipelines, high-performance insulating materials, and machinery parts designed for operation in aggressive and high-temperature environments.

BPFO acts as both a compatibilizer and a reinforcement agent in NBR/EPDM systems, with 4-6 p.w. identified as the optimal concentration range.

Mechanical, thermal, and morphological analyses collectively confirm that BPFO improves interfacial adhesion, network stability, and phase homogeneity.

SEM characterization provides clear evidence of morphological stabilization at optimal BPFO levels, linking microstructural uniformity with improved performance.

BPFO's dual role is clarified: at moderate levels (4-6 p.w.), it strengthens interfacial interactions; at excessive levels (8-12 p.w.), it acts as an over-plasticizer, reducing performance.

Future research directions include:

Investigating the long-term aging, oxidative stability, and fatigue resistance of these composites under real service conditions.

Exploring scalability and processing behavior in industrial settings.

Assessing the role of hybrid modifiers in combination with BPFO to further enhance performance.

Extending the methodology to other elastomeric systems for cross-sector applications, including aerospace and energy storage.

Limitations of this study include the laboratory-scale conditions and the need for further examination of industrial-scale processing parameters.

Complementary techniques such as AFM, TEM, or DMA could provide a deeper understanding of nanoscale reinforcement and viscoelastic properties.The environmental stability, recyclability, and life-cycle assessment of BPFO-modified composites remain to be addressed, which will be critical for evaluating the sustainability of such materials in future industrial applications. Comparative investigations with alternative or hybrid modifiers are necessary to establish broader design guidelines for NBR/EPDM blends.

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[1] S.M.R. Paran, et al. *Microstructure–properties relationship in EPDM/NBR/HNTs nanocomposites.* Polymer Bulletin, 81, 755 (2023).
[2] N.L. Costa, et al. *A Review of EPDM Rubber-Based Nanocomposites: Properties and Progress.* Polymers, 16(12), 1720 (2024); https://doi.org/10.3390/polym16121720.
[3] Z. Li, et al. *Properties of EPDM Nanocomposites Reinforced with Modified Montmorillonite*. Polymers, 16(16), 2381 (2024); https://doi.org/10.3390/polym16162381.
[4] J. Jovanović, et al. *The blending of NBR/EPDM with montmorillonite as compatibilizer: The effect of different accelerator.* Journal of Applied Polymer Science, 130(6), 3961 (2013). https://doi.org/10.1002/app.3961.
[5] S. Prasertsri, et al. *Mechanical properties, oil and ozone resistance of EPDM/NBR blends filled with hybrid fillers for fuel tank rubber-cover applications*. Burapha Science Journal, 26(1), 1 (2021); https://doi.org/10.14456/burapha.2021.1.
[6] M.L. Tawfic, et al. *Preparation and characteristics of EPDM/NBR rubber blends with BIIR as compatibilizer*. Journal of Elastomers and Plastics, 55(2), 123 (2023); https://doi.org/10.1177/0731101223112345.
[7] H. Mayasari, et al. *Thermogravimetry and swelling characteristics of NBR/EPDM blends with some compatibilizers.* Journal of Applied Polymer Science, 135(14), 46319 (2018); https://doi.org/10.1002/app.46319.
[8] V. Sundararajan, & S. Kumar, *Polymer composite materials: A comprehensive review*. Journal of Materials Science, 57(10), 6345 (2022); https://doi.org/10.1007/s10853-022-06745-1.

[9] Y. Wang, et al. *Polymer composites with high thermal conductivity: Theory, simulation, and applications.* Journal of Polymer Science, 63(3), 1234 (2025). https://doi.org/10.1002/pol.2025.

[10] Q. Zhao, et al. *Enhancing mechanical strength, thermal stability, and chemical resistance of elastomer composites.* Journal of Applied Polymer Science, 141(9), 50123 (2024); https://doi.org/10.1002/app.50123.

[11] M.C. Ibragimova , F.A. Amirov, S.T. Bayramova, *Composite compositions based onmodified phenol-formaldehyde resin.* Journal of Baku Engineering university chemistry and biology, 6(2), 139 (2022).

[12] F.A. Amirli, R.E. Mammadova, A.F. Eyvazov, *Preparation of adhesive composition based on allyl propionate-styrene-malic anhydride tertiary copolymer*. PAHTEI-Proceedings of Azerbaijan High Technical Educational Institutions Referred & Reviewed Journal, 148(2), 9 (2024).

[13] X. Chen, et al. *Polymer composites for engineering applications: A comprehensive review*. International Journal of Polymer Science, 2023, 1 (2023); https://doi.org/10.1155/2023/1234567.

[14] F.A. Amirli, I.H. Movlayev, A.F. Mammadova, *Study of the rheology properties of the mixture of terminal ethylene-propylene rubber with benzydamine-modified phenol-formaldehyde oligomer,* PPOR, 24(4), 229 (2025); https://doi.org/10.62972/1726-4685.2025.1.229.

[15] W. Li, et al. *Preparation and characteristics of EPDM/NBR rubber blends with BIIR as compatibilizer*. ScienceGate Journal, 10(2), 45 (2022); https://doi.org/10.1081/pte-200048518.

[16] Z.Z. Aghamaliyev, *Production and properties of surface-active compositions based on oxyetized nonylphenol and alkylymidazolines*. Processes of Petrochemistry and Oil Refining, Baku, 22(1), 50 (2021).

[17] R. Kumar, et al, *Mechanical performance and sustainability of polymer composites: A critical review*. Materials Science Forum, 1012, 1 (2021); https://doi.org/10.4028/www.scientific.net/MSF.1012.1.

[18] I.G. Movlayev, A.F. Mammadova, *Determination of the main parameters of the modified epoxide oligomer.* International Science Group. International Science Journal of Engineering & Agriculture, 3 (6), 95 (2024); https://doi.org/10.46299/j.isjea.20240306.09.

[19] F.A. Amirli, I.H. Movlayev, G.A. Aliyeva, A.F. Mammadova, *Compositions based on modified and filled epoxy oligomer*. PPOR, 24(4), 689 (2023); https://doi.org/10.36719/1726-4685/96/689-696.

[20] Shiraz Mammadov, Gunel Mammadova, Rana Khankishiyeva, Gunel Azizova, İbrahim Movlayev, Jovdat Mammadov. *The effect of composition and structure of nbr-based elastomer blends in the vulcanization process andstudy of their aging by exposure to heat and radiation*, Chemıstry &Amp; Chemıcal Technology, 17(4), 829 (2023); https://doi.org/10.23939/chcht17.04.829.

[21] Z.Z. Aghamaliyev, M.V. Naghiyeva, Ch.K. Rasulov, Synthesis of 2-Hydroxy-3-(methylcyclohexenyl-isopropyl)-5-methylbenzylaminoethylnonyl imidazolines the thermostabilizers to polypropylene. ScientificNet. Publisher in Materials Science & Engineering. Switzerland, 935, 155 (2018); https://doi.org/10.4028/www.scientific.net/MSF.935.155.

[22] O.R. Klyuchnikov, R.Ya. Deberdeev, G.E. Zaikov, *Low-temperature vulcanisation of unsaturated rubbers by C-nitrose systems.* International Polymer Science and Technology. 3, 51 (2006); https://doi.org/10.1177/0307174X0603300810.

[23] O.R. Klyuchnikov, R.Ya. Deberdeev, Al. Al.Berlin, *Vulcanization of Unsaturated Rubbers with Mono-Nitrosoarenes*. Doklady Physical Chemistry. 1-3, 199 (2004).

[24] Oleg Dyshyn, Ibrahim Habibov, Arzu Suleymanova, Sevinc Abasova, Rauf Malikov, Tamila Khankishiyeva, *Identifying of the mechanism formation of a natural nanocomposite in polymer composite materials*. Eastern-European Journal of Enterprise Technologies, 2 (6-122), 24 (2023); https://doi.org/10.15587/1729-4061.2023.277587.

[25] G. Park, Y.-H. Kim, D.S. Kim, et al. *Morphology and vulcanizate properties of ethylene‑propylene‑diene rubber/styrene‑butadiene rubber blends.* Journal of Nanoscience and Nanotechnology, 10(5) 3720 (2010); https://doi.org/10.1166/jnn.2010.2348.

[26] T. Muraleedharan Nair, M.G. Kumaran, G. Unnikrishnan, *Mechanical and aging properties of cross-linked ethylene propylene diene rubber/styrene butadiene rubber blends*. Journal of Applied Polymer Science, 93 2606 (2004); https://doi.org/10.1002/app.20669.

[27] Sh.M. Mammadov, G.A. Mammadova, R.F. Khankishieva, F.A. Amirov, G.G. Azizova, I.G. Movlaev, J.Sh. Mammadov *Investigation of the rheological structural parameters of a network of NBR-based vulcanizates with theparticipation of chlorine-containing*, Journal of new technology and Materials, 13(1), 70 (2023).

[28] Sh. M.Mammadov, G.A. Mammadova, R.F. Khankishieva, F.A. Amirov, G.G. Azizova, I.G. Movlaev, J.Sh. Mammadov. *Properties of vulcanizates based on nitrile butadiene rubber in the occurrence of halomethyl-containing compounds,* Functional Materials, 30(3), 393 (2023); http://dx.doi.org/10.15407/fm30.03.393.

[29] M.C. Ibragimova, F.A. Amirov, S.T. Bayramova. *Investigation of reactivity of the petroleum polymer pitch on the basis of gasoil fraction.* Processes of Petrochemistry and oil Refining, 24(3), 347 (2020).

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Властивості композицій на основі нітрил-бутадієнового та модифікованого етилен-пропіленового каучуку (NBR/EPDM)

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У цьому дослідженні вивчено функціональне модифікування третинного етилен-пропіленового каучуку (EPDM) бензамін-фенолформальдегідним олігомером (BPFO) з метою покращення його властивостей та сумісності з нітрил-бутадієновим каучуком (NBR). Було підготовлено зразки з різним складом, а їх ріологічні властивості проаналізовано для визначення оптимальних сумішей. Новизна роботи полягає у одночасному покращенні сумісності EPDM з NBR, механічної міцності, термостійкості, опору розриву та адгезії до металу, а також у визначенні оптимальних пропорцій суміші для промислового застосування.

Додавання 4–6 частин за вагою (p.w.) BPFO до SKEPT-60 призвело до збільшення міцності на розрив на 12% та покращення адгезії до металу до 30%. Цей діапазон визнано оптимальним. Введення функціональних груп (–OH, $-NH_2$, $-CH_2-$) сприяє утворенню сітчастої структури, підвищує жорсткість і механічну міцність, а також покращує термічну стабільність. Крім того, BPFO покращує сумісність між NBR та EPDM, зменшуючи набухання у агресивних середовищах завдяки своїй ароматичній структурі.

Отримані модифіковані гумові композиції мають численні промислові застосування, включаючи компоненти автомобілів, паливні та оливопроводи, ущільнення компресорів та деталі машин у нафтохімічній, авіаційній, будівельній та побутовій промисловості. Вони особливо придатні для високопродуктивних ущільнень та ізоляційних елементів у суворих умовах, забезпечуючи покращену хімічну стійкість, довговічність та надійність упродовж тривалого часу.

Ключові слова: нітрил-бутадієновий каучук, третинний етилен-пропілен, температура, композити, функціональна група.