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Properties of Elastomeric Compositions with Highly Dispersed Carbon Additives

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The effect of highly dispersed carbon additives (HDCA) obtained in high-voltage discharge plasma on properties of elastomeric compositions is investigated. Some tests to determinate tensile strength, stretching strain, abrasion resistance, hardness and resistance to heat aging of highly filled rubbers based on raw rubber for general and special application are carried out. It is shown that HDCA addition permits to improve performance characteristics of elastomers based on butadiene-acrylonitrile rubber.

Keywords: Carbon Additives, Tensile Strength, Stretching Strain, Abrasion Resistance, Hardness, Heat Aging Resistance, Butadiene-Styrene Rubber Synthetic-Styrene Rubber, Butadiene-Acrylonitrile Rubber.

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1. INTRODUCTION

At present development of ways of production, investigation of properties and application of various high-dispersion materials is increasingly carried out in order to create highly effective composite materials.

Methods of nanomaterial production lie in realization of transfers "gas–liquid–solid", "liquid–solid" or "gas–solid" under highly non-equilibrium conditions. This result in the fact that materials composed of high-dispersion particles are characterized by a combination of odd properties and differ from properties of the same materials in bulk [1-2].

Much attention is paid to development of some direction in the field of investigating new types of materials based on carbon and their application in manufacturing new composite materials [3-5]. Its morphological states which appear to be of interest for research are diamond films precipitated from the gaseous phase, ultrafine particles, nanotubes and fullerenes.

The aim of the research was to determine the effect of highly dispersed carbon additives technical properties of filled rubbers based on raw rubber for general and special purpose.

2. MAIN PART

We investigated filled rubbers based on raw rubber for general application (synthetic-styrene rubber SKI-3, oil filled butadiene-styrene SKMS-30 ARKM-15, stereoregular butadiene SKD) and special application (butadiene-acrylonitrile rubber). Highly dispersed carbon additives in dosages 0,05–0,20 phr were added into the rubber mix formulation. Samples without nanoadditives in their composition served as the objects for comparison. Codes, mechanical parameters and their change after thermal agency of rubbers under analysis are given in Table 1.

Table 1 – Codes, mechanical parameters and their change after thermal agency of rubbers under analysis

Code of mix	HDCA dosage, phr	Raw rubber	Raw rubber content, phr	Fillers	Fillers content, phr	Elongation at break, %	Tensile strength, MPa	Change of elongation at break , %	Change of tensile strength, %
A1	0	SKI-3	75	Carbon black П-803	15	640	22,2	–55,1	–62,2
A2	0,05	SKD	25			660	20,7	–55,2	–52,7
A3	0,1			П-234	15	660	21,5	–55,6	–54,9
A4	0,15			calcium carbonate	10	620	19,8	–54,1	–59,1
A5	0,2					590	18,1	–53,7	–61,4
B1	0	SKI-3	73	Carbon black N330	53	610	18,9	–25,6	–33,9
B2	0,05	SKMS-30 ARKM-15	27			600	18,5	–26,5	–31,5
B3	0,1					600	18,2	–25,9	–29,6
B4	0,15					610	18,3	–25,0	–30,1
B5	0,2					620	18,1	–25,8	–30,4
C1	0	BNKS-18A	100	Carbon black П-803	129	220	11,5	–50,0	20,1
C2	0,05					210	11,5	–47,0	25,0
C3	0,1					210	11,6	–42,3	28,0
C4	0,15					210	11,3	–43,2	27,4
C5	0,2					200	11,1	–44,0	26,8

The initial nanomaterial was obtained in high-voltage discharge plasma, and after comprehensive treatment with acids. After that it composed of carbon tubes with some fibre admixtures and amorphous carbon particles.

Physico-mechanical characteristics – tensile strength and breaking elongation were de-fined in accordance with GOST 269-66. Tests to define rubber resistance to heat aging and aggressive media impact were carried out in accordance with GOST 9.024-74 (the testing time was 72 hours, the testing temperature of samples based on general-purpose rubbers was 100 °C, and on the basis of butadiene-nitrile rubbers – 125 °C) and GOST 9.030-74.

3. DISCUSSION OF THE RESULTS

Application of rubber as a construction material is conditioned by its unique ability to deform completely, without damage under low mechanical load, to change its shape at mechanical loading preserving its constant scope, to restore its original shape after remov-ing the load, to absorb the mechanical energy at deforming and diffuse it at restoring

The study of rubber mechanical properties is based on investigation of its physical and chemical structure, nature of highly elastic deformation and relaxation processes. In the majority of cases theoretical knowledge permits to explain peculiarities of mechanical behavior of definite rubber but it can't be a sufficient basis for creating rubbers with specified mechanical properties. It is accounted for by the fact they are compositions of complex structure and interaction of individual components may occur on molecular and supermolecular levels. So to define the carbon nanomaterial effect on rubber properties we made some tests on revealing dependence of rubber physical and mechanical properties on the rubber type and highly dispersed carbon additives dosage. The obtained results are presented in Table. 1.

The analysis of physical and mechanical properties of vulcanizates revealed that used of highly dispersed carbon additives doesn't have much effect on rubber hardness, tensile strength and elongation at break. Perhaps, it is accounted for by a large amount of fillers, including active grades of carbon black. There was observed some decrease of tensile strength in rubbers based on a combination of SKI-3 and SKD.

The data given in Table 1, indicate that of highly dispersed carbon additives in rubber composition contribute to increase of their thermal stability. The most effective results were obtained in tests on adding highly dispersed carbon into rubber mixes based on butadiene-nitrile raw rubber with acrylonitrile content equal to (of) 17-23 % wt.. It should be noted that, under the temperature effect decrease of elongation at break is slower in rubbers with HDCA.

It may be due to the fact that in the process of rubber mix preparation functional groups on the highly dispersed carbon additives surface can react with raw rubber macromolecules and carbon black surface thus increasing contribution of chemical bonds to interaction of the system "carbon black – elastomeric matrix". Conditions of rubber service and application should be taken into account in analyzing technical properties of vulcanizates. Thus, rubbers based on a combination of synthetic raw rubber (code "B") are assigned for tyre manufacture and used for producing parts sided bead and tire tread respectively. Rubber based on butadiene-nitrile raw rubbers and on a combination of SKI-3 and SKD are used for producting general mechanical rubber goods for various application, which should be sufficiently oil-, petrol- and weather-resistant. Taking into account the service conditions there were carried out same tests on determining rubber abrasion resistance.

The data on rubber abrasion resistance is given in Fig. 1.

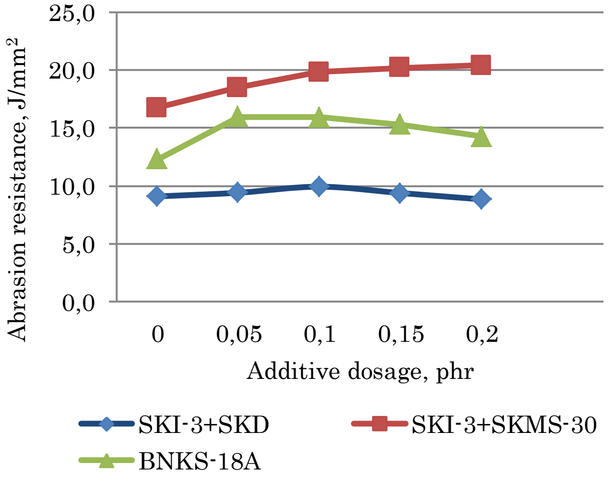

Fig. 1 – Abrasion resistance of rubbers under analysis

The data presented in fig. 1, indicate that HDCA addition results in increase rubber abrasion resistance. However, the nature of the effect on this parameter depends on the elastomeric matrix. Increase of this parameter value in using polar raw rubber reaches 25-30% and in case of raw rubber for general (application) purpose it is lower. Thus, the use of highly dispersed carbon additives in rubber based on a combination stereoregular butadiene rubber and butadiene-styrene with isoprene rubber allowed to increase their abrasion resistance by 22 and 16% respectively. The rubber samples under test were subjected to abrasive wear. Increase of abrasion resistance in this case, perhaps, is possibly due to participation of highly dispersed carbon additives in the vulcanization process with formation of stronger links. This vividly screen in increase of Shore A hardness (approximately 5 conv. units. Shore A it increase of HDCA dosage). Increase of rubber hardness in the analyzed types of wear contributes to its decrease, since there occurs transition from "rolling" wear to abrasive one.

4. CONCLUSION

Addition of carbon nanomaterials into rubber formulations based on general-purpose rubbers should be carried out with the account of the formulation, nature of polymer and service characteristics. In this case, as our investigation showed there occurs increase of certain properties of rubbers. Thus it is most reasonable to create new elastomer compounds with the use of CNM as modifying additives on the basis of butadiene-nitrile raw rubbers. Vulcanizates of such structure are characterized by high abrasion resistance, resistance to heat aging

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