Polymer-bitumen composition for insulation purpose

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Abstract. The aim of the work is to develop a polymer-bitumen insulating composition based on petroleum bitumen and secondary products of the chemical industry. Investigated the physical and chemical properties of the secondary product of the production of polypropylene, the adsorbent of the oil and gas industry, the powder of crushed tires. It has been established, the technology of their introduction into the compositions and their influence on the technological and physical-mechanical properties of polymer-bitumen compositions has been investigated, and their optimal content has been determined.

1 Introduction

Currently, the literature and patent sources [1-3] describe a number of methods for using by-products of the production of alcohols and phthalic anhydride in order to obtain a plasticizer for bitumen and asphalt mixtures. At the same time, flavored products also exhibit plasticizing abilities. For the conditions of the republic, extracts of selective purification of oils with phenol and products of oil shale resins can serve as such products. The production of petroleum bitumen, based on compounding and the introduction of additives, has great flexibility. The use of a scientific and technological approach in the bitumen production in the preparation of raw compounds of the optimal composition for oxidation and the production of high-quality bitumens modified with various additives will intensify bitumen production with an increase in the production of petroleum bitumens, eliminating the negative impact of the unregulated composition of the oxidation raw material on the results of the oxidation process and obtaining bitumen products with given properties.

The choice of objects of study was due to theoretical and analytical conclusions and conclusions in the direction of increasing the resources of the composition based on petroleum bitumen, improving their physical and mechanical properties, taking into account the provisions of the theory of petroleum dispersed systems.

2 Methods

The main characteristics of the prepared samples were analyzed by the following methods: softening point (Tp) is the temperature at which bitumen changes from a relatively solid

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state into a liquid state, determined by the "ring and ball" method (R&B) according to GOST 33142-2014; penetration was determined with a penetrometer according to GOST 33136-2014, the penetration depth of the needle by 0.1 mm was taken as the unit of penetration; brittleness temperature (Thr), determined according to GOST 33143-2014; composition change after heating (Δm), determined according to GOST 18180-2017; extensibility (ductility) of the composition is characterized by the distance at which it can be pulled into a thread before breaking, determined according to GOST 33138-2014; conditional viscosity, determined according to GOST 11503-2014 and GOST 18659-2016; flash point was determined according to GOST 33141-2014; compressive strength, determined according to GOST 31015-2012; crack resistance was determined by the tensile strength during splitting according to GOST 31015-2012.

3 Results and discussion

Bituminous composite insulating materials resistant to heat, cold, bending, stretching, friction and action of dynamic forces are used for coating concrete products, roofs of houses and pipelines. Therefore, special attention is paid to the creation of polymer-bitumen compositions with predetermined technological, physical-mechanical, dynamic properties in order to increase their resistance to frost, heat, bending, friction, stretching and service life.

It is known that sharply continental weather conditions in Central Asia lead to rapid wear of the insulating coatings of concrete products, roofs of houses and pipelines. This is due to the fact that bitumen, which is the basis of the composition used in them, is not resistant to all weather effects (Table 1).

To improve the thermal and frost-wear resistance of BNK-5 insulating bitumens and coatings based on them, ingredients based on local raw materials were selected and their physical and chemical properties were studied.

The carbon-containing material is a brittle substance with a grayish odor, which, after cooling, was crushed in a dismembrator and the particle size distribution was determined. Based on the studies, it was shown that the carbon-containing material particles accounted for 63.0% of the 0.063 nm fraction, 24.0% of the 0.25 nm fraction, 9.0% of the 0.5 nm fraction and 3.0% of the 0.045 nm fraction. Its physical properties such as bulk density, acidity, humidity, ash content were studied (Table 1).

Table 1. Physical and chemical properties of crushed carbonaceous material

ρ_n, g/sm^3	pH	A^d, %	W^a, %
0.408 ± 0.02	6.5-5.4	22.70 ± 0.44	0.40 ± 0.05

Where: A^d – ash content on dry basis, W^a – analytical moisture content.

X-ray diffraction analysis showed that the composition of the carbon-containing material contains 88.24% amorphous carbon, 7.59% calcite, 1.14% zinc oxide, 1.21% ankerite and other components (Fig. 1).

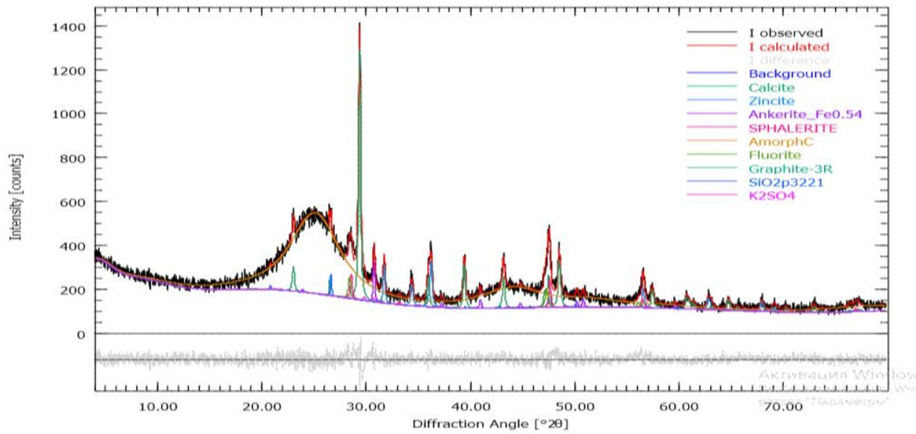

Fig. 1. Radiographs of carbon-containing material obtained by pyrolysis of worn-out car tires

It's thermal stability was studied by the derivatographic method and the first stage took place in the temperature range of 150-640 °C and the weight loss was 3.46%, and in the second stage - in the temperature range of 650-900°C and the weight loss was 15.7%. The structure of the carbon-containing material was studied by the IR-spectroscopic method. In its IR spectrum, absorption lines with very low intensity were observed in the region > 3600 cm-1. It showed that some organic alcohols, water and humid air were adsorbed on a dry surface (Fig. 2).

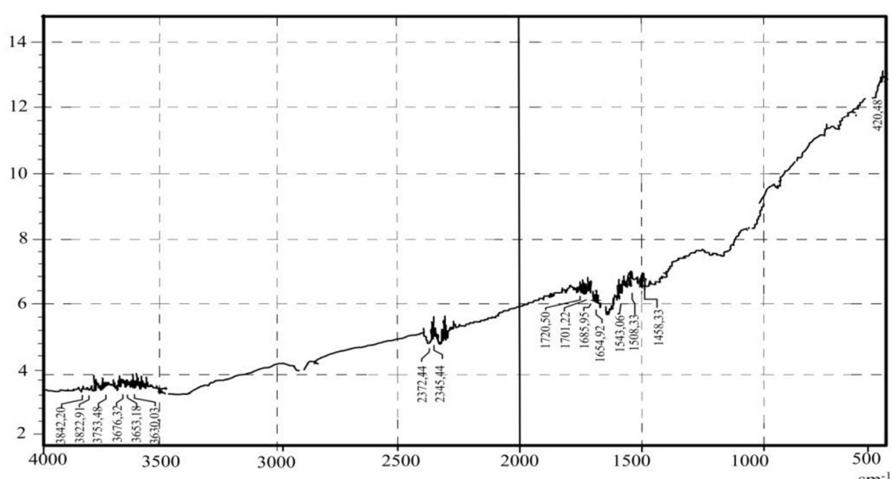

Fig. 2. IR spectra of a carbonaceous material

The absorption lines belonging to the C≡C bond also belong to the $–CH_2$ group, which is a very weak absorption line in this region and in the region of 2916 sm^{-1}, in addition, the absorption of hydrocarbons into the resulting structure was observed. Areas of low intensity absorption belonging to the group of unsaturated hydrocarbons (-CH = CH-) are usually shown in the areas of 693 sm^{-1}, 600 sm^{-1}, and absorption lines characteristic of the CH_2 and CH_3 groups in the area of 2372 sm^{-1}. and area 2345 sm^{-1}, 1720- Aromatic hydrocarbons in the region of 1684 sm^{-1}, CH_3C, $(CH_3)_2C$-groups in the region of 1458-1543 cm^{-1}, absorption lines with a width of 1100-1000 sm^{-1} $(SiO_4)_4$ - and SiO2, while the corresponding

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absorption lines appear at 800 sm^{-1}. White dry n-$SiO_2 \cdot nH_2O$ (BS-50) is used as a filler in car tires, and Me-O absorption lines of metal oxides were observed in the range of 400 sm^{-1} - 500 sm^{-1}. This means that the carbon retaining material can be used as an active ingredient for a polymer-bitumen composition.

Pyrolysis resin is a secondary raw material for the production of polypropylene, which is a black solid, odorless (Table 2). As can be seen from the table, its composition consists mainly of alkanes, dienes, olefins, cycloalkanes and arenes formed during the pyrolysis of natural gas, with a molecular weight of 1000-1200 and a melting point of 180°C.

Table 2. Chemical composition of gas pyrolysis resin

Number of carbons, %	Alkanes	dienes	Olefins	Cycloalkanes	Arenas	Σ
5	0.8	0.89	4.91	0.19	0	6.79
6	0.22	0.41	3.87	0.41	32.94	37.85
7	0.25	0.14	0.84	0.45	11.23	12.91
8	0.12	0.08	0.18	0.48	9.75	10.61
9	0.04	0.1	0.04	0.15	7.56	7.89
10	0.03	0.11	9.07	0.4	5.23	14.84
11	0.18	0.69	2.95	0	0.47	4.29
12	0	0.15	1.84	0	0	1.99
Σ	1.64	2.57	23.7	2.08	67.18	97.17

Crushed tire powder was chosen as the main ingredient of polymer-bitumen compositions. (Table 3).

Table 3. Properties of ground tire powder

Indicator	Properties
Particle size, mm	0.25 – 2.8
Density, kg /m^3	1250 – 1256
Bulk density, kg/m^3	430 – 435
Specific surface area, sm^2/g	1100 – 2200
Hydrogen indicator, pH	7 – 8
Fat swelling, ml/100 г	92 – 105

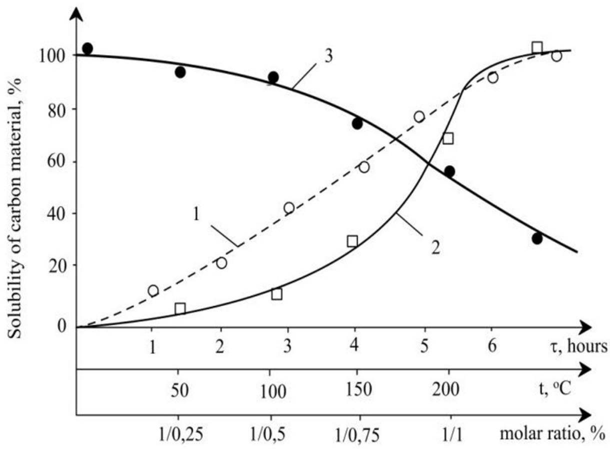
As can be seen from the table, the properties of the selected ingredient are sufficient for use in compositions and it is recommended to use it in the composition of polymeric bitumen.
Secondary alkanolamines, when studying their composition, it was found that they are formed as a result of the adsorption of sour gases (H_2S, CO_2, SO and their compounds) and salts. Given the presence of sour gases in secondary alkanolamines, they were studied for their use as accelerators in the structuring of the polymer-bitumen composition. Before using them, the water was removed from them.

Table 4. Physical and chemical properties of secondary alkanolamines

Solutions of alkanolamines	Concentration		Boiling temperature, °C, (180 kPa)	Freezing point, °C	Viscosity (0 °C, 103 Pa*c)
	kmol /m^3	%			
* UMEA	2.5	65	123	-11	1.6
** UDEA	2	71	124	-12	2.0
*** UMDEA	2	74	126	-14	2.9

**UMEA - used monoethanolamine; **UDEA - used dietanolamine; ***UMDEA - used methyldiethanolamine.*

The influence of time, temperature and the ratio of bitumen and crushed powder on the melting process of crushed tire-based powder in bitumen was studied (Fig. 3).



1-time; 2-temperature; 3 material ratio

Fig. 3. Influence of time, temperature and ratio of bitumen and crushed powder on the process of its melting in bitumen.

As can be seen from the figure, the temperature of the technological process of melting carbon-containing material is 180 °C, the time is 6-8 hours, the ratio of bitumen and crushed powder is 1:3. In this process, the crushed powder based on active organic compounds of bitumen swells at high temperatures for the first four hours, then for three hours the process of devulcanization of the vulcanization network. To increase the thermal stability of the composition, gas pyrolysis resin was added to its composition and the effect of its content was studied (Fig. 4).

As can be seen from the figure, the optimal amount of gas pyrolysis resin was 3-5% of the total volume, and at the same time, the thermal stability of the composition increased by 120 °C. This state is known above because the softening temperature of the pyrolysis resin is 180 °C. The decrease in its melting is associated with an increase in the melting temperature of the composition, in which a certain amount of carbon material could react with active centers formed as a result of rupture of vulcanization networks.

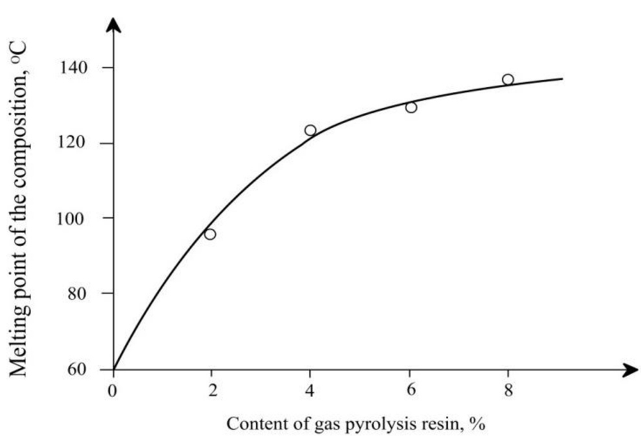


Fig. 4. Influence of the content of gas pyrolysis resin on the melting point of the composition.

It is known that polymer-bitumen compositions mainly consist of organic materials, so it is desirable to increase the volume without reducing its properties. In this case, it was studied by adding to its composition a secondary product formed during the pyrolysis of obsolete rubber products and tires - a carbon-containing material (Table 5). Positive results were achieved when it was added to the composition of more than 90% of the total volume, which made it possible to improve the technological and technical properties of the composition. This is due to the fact that the by-product is miscible with the composition because it is an organic material, and the pores formed at high temperatures may be due to the absorption of macromolecular compounds in the composition and the occurrence of interfacial convergence.

Table 5. Influence of carbon-containing material on polymer-bitumen properties

Name of indicators	Content of carbonaceous material, %			
	30	60	90	120
Melting temperature, °C	86	113	143	150
Elongation (25 °C), mm	67	54	40	25
Penetration, mm^{-1}	27	24	20	18
Adhesion strength to the base, MPa	1.2	1.6	1.9	2.6

This condition ensures the formation of a network in the composition and increases its resistance to heat and cold. Taking into account the addition to the polymer-bitumen composition, it is recommended to add vulcanizing ingredients to increase its strength. In this case, secondary alkanolamines have been shown to be added at 5% as a vulcanization accelerator.

4 Conclusions

Based on the developed ingredients, the composition and technology for the production and use of heat-frost-resistant, wear-resistant polymer-bitumen compositions for the insulation of concrete products, roofs of houses and pipelines in sharply continental conditions are recommended.

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