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STUDY OF THE USING OF A MODIFICATION BASED ON SULFUR AND CROTONALDEHYDE IN THE PRODUCTION OF SULFUR CONCRETE

Abstract*: In this article has been studied a method is proposed for obtaining modified sulfur with high deformation strength and adhesive properties as a result of sulfur modification with the help of crotonaldehyde. The high thermal and relaxation properties of the obtained modified sulfur are explained by the formation of a volcanic network. Also, crotonaldehyde was first used as a sulfur modifier and the optimal conditions for the copolymerization reaction were determined. The resulting compositions proved to be stable during storage and are recommended for the production of sulfur concrete.*

Key words*: crotonaldehyde, sulfur concrete, modification, IR spectrum, a gamma spectrometer.*

Language*: English*

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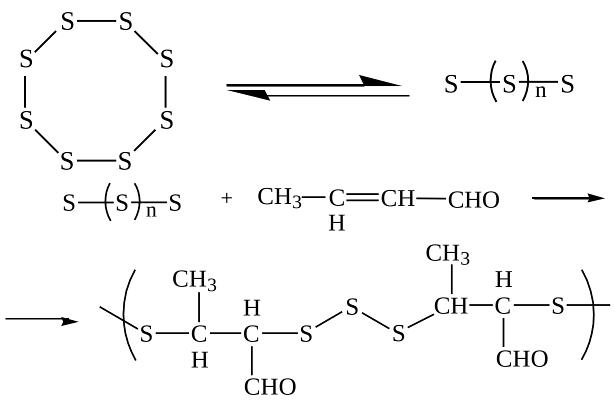
Introduction

Today, the world pays special attention to the creation of new modified sulfur binders. In this regard, modified sulfur concrete can be used to produce products that are resistant to industrial, climatic and other types of aggressive environments. In industrialized countries, work is underway to obtain a number of modified sulfur concretes using unsaturated aromatic compounds based on ethylidene-norbornene and other unsaturated organic compounds. However, sulfur concrete made from unmodified sulfur has limitations for practical use because it has poor water resistance and is more brittle than conventional concrete. Based on the foregoing, it is necessary to develop a technology for producing sulfur concrete obtained using modified sulfur-containing binders. Due to the fact that fossil fuels are burned to fire kilns and the stoichiometric release of carbon dioxide when limestone is converted to calcium oxide, this process generates about one ton of carbon dioxide for every ton of cement and accounts for 5% of global anthropogenic CO2 production [1-4]. In 2007, world sulfur production was about 1,000 million tons. By 2009, 120 million tons of sulfur had been produced in Korea. 90% of the sulfur produced in Korea is a by-product of desulfurization in the oil refining process. [5-8]. Sulfur is expected to rise steadily in the future. If there is no counter plan, huge waste disposal costs will be required. As a result, the use of sulfur as building materials such as asphalt and concrete has been considered. On the other hand, climate change, called global warming, is one of the most serious global problems that can threaten the sustainability of human society[9-10].

EXPERIMENTAL PART

1. Modification of sulfur with crotonaldehyde and production of sulfur concrete.

Sulfur was heated in a glass beaker to 185°C in a thermostatically controlled oil bath with constant stirring until a transparent viscous orange molten sulfur phase was formed. Crotonaldehyde was then directly added to the molten sulfur phase. The resulting mixture was stirred at 185–190°C for 60–70 min, which led to some decrease in the viscosity of the reaction medium and the formation of black and yellow products for crotonic aldehyde comonomers with sulfur, respectively. The resulting products, upon completion, were taken directly from the beaker with a spatula and allowed to cool to room temperature. The reaction scheme for the polymerization of crotonaldehyde with sulfur is shown in Scheme 1.



Scheme 1. Scheme for the synthesis of polymeric sulfur.

The resulting sulfur copolymer was heated to 180–190°C in a stainless steel beaker equipped with a mechanical stirrer in a thermostatically controlled oil bath until a molten phase formed. Sand, crushed stone, fly ash were added to the molten medium of modified sulfur, and the resulting mixture was additionally heated at this temperature to form a homogeneous admixture of concrete with constant stirring in a molar ratio of 1:2.5 (polysulfide copolymer sand, gravel, ash). The viscous mixture was placed in a self-made mold, and then immediately placed in an oven heated to 180–190 °C, held for 30 minutes, cooled to room temperature, and carefully removed from the mold.

RESULT AND ITS DISCUSSION

The IR spectrum of modified sulfur in the regions of 2850-1470 cm-1 has absorption bands, confirming the presence of -CH2- groups, and absorption bands in the region of 1650 cm-1, confirming the presence of the –C=O group in the free state. The IR spectrum contains absorption bands in the region of 3400 cm-1 corresponding to –OH groups. The bending vibrations of all active groups appear as strong narrow bands between the usual bending vibration bands –CH–O– in the region of 1400 – 1465 cm-1. The presence of groups containing sulfur S=O and S–H in the region of 2343–2368 cm–1, a wide intense band confirms sulfur-containing compounds in the regions of 1200–1100 cm–1, 1040–1060 cm–1.

In addition, narrow low-intensity bands containing bonds of a sulfur-containing compound appear on IR spectroscopy in the regions of 1060 cm-1 and 1015 cm-1. When considering the IR spectra of modified sulfur, intense -CH2-O- groups are visible with dimer indices of 1400-1440cm-1 (Fig. 1) .

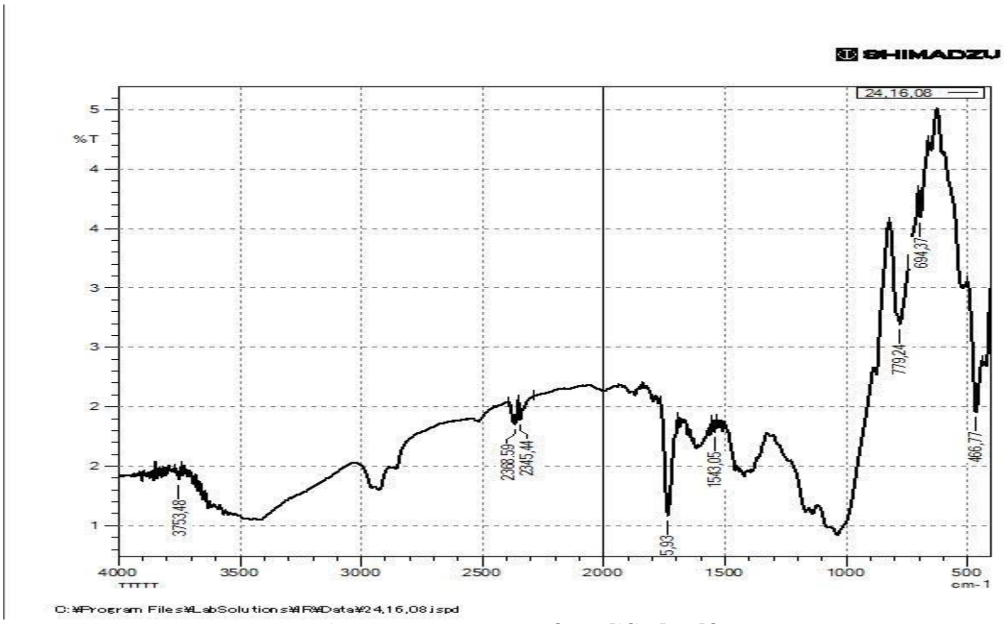


Fig. 1. IR spectrum of modified sulfur.

2. Study of radionuclides of sulfur concrete and Portland cement.

Considering the advantage and convenience of sulfur concrete, we analyzed it on a gamma spectrometer. Accordingly, test conditions: T-22 °C, humidity -63%, illumination-300 lux, specific activity Bq/kg.

According to SanPiN 0193-06, they are used in construction at a level of less than 350 Bq/kg. In the analysis of sulfur concrete, its radionuclides averaged 127 Bq/kg. Sulfur concrete contains modifier-26%, sand-54%, ash (ash) -16% and various metal oxides - 4%. Additives and fillers added to sulfur concrete, i.e. radionuclides in sand and gravel were analyzed using gamma spectrometry. Accordingly, test conditions: T-22`C, humidity -63%, illumination-300 lux, specific activity Bq/kg (tables 1-3) .

Table 1. Analysis of radionuclides in sulfur concrete using a gamma spectrometer.

Name	Sample oderal number	Ra-226	Th-232	K-40	Aeff.	Aeff.m
Серобетон	1	9,11	36,9	84,1	64,6	136
	2	10,2	35,1	84,7	63,4	130
	3	14,0	29,5	85,7	59,9	119
	4	11,2	36,2	82,5	65,6	128
	5	18,1	31,8	84,0	66,9	122
	Medium	12,5	33,9	84,0	Aeff Medi=64,08	Aeff.m Medi=127 Bq/kg.

Table 2. Analysis of radionuclides in sand on a gamma spectrometer.

Name	Sample oderal number	Ra-226	Th-232	K-40	Detection mistake, %	Aeff. Bq/kg.
Песок	1	20,9	6,86	25,3	6,2-10,8%	91,1
	2	22,6	3,86	25,9	6,2-10,9%	122
	3	19,5	5,87	27,5	5,8-10,3%	97,6
	4	21,3	4,12	26,4	6,0-10,4%	114
	5	21,1	4,47	25,1	6,1-10,2%	109
Aeff.m = 107 Bq/kg.						

Table 3. Analysis of radionuclides in "rubble" on a gamma spectrometer.

Name	Sample oderal number	Ra-226	Th-232	K-40	Detection mistake, %	Aeff. Bq/kg.
Macadam	1	20.3	5,17	25,9	6,2-10,8	103
	2	20.5	4,02	49,8	6,2-10,9	175
	3	19.6	4,03	27,9	5,8-10,3	114
	4	17.8	5,49	39,9	6,0-10,4	96,4
	5	20.6	3,28	41,3	6,1-10,2	129
Aeff.m = 123,48 Bq/kg.						

Portland cement M-500 was also analyzed on the MKS-AT-1315 gamma spectrometer. Accordingly, test conditions: T-22 °C, humidity -63%, illumination-300 lux, specific activity Bq/kg.

3.Study of the results of electron microscopic analysis of sulfur concrete

On fig. 2. It can be seen that with the addition of 5 g of crotonaldehyde per 100 g of sulfur, the particle sizes of the dispersed phase increase significantly from -0.1 to 0.5 µm, while with the addition of 3 g of crotonaldehyde per 100 g of sulfur, there is no similar effect. observed. If crotonaldehyde is added to plasticized polymeric sulfur, then a significant increase in the size of the dispersed phase occurs in direct proportion to the increase in the content of the modifying additive.

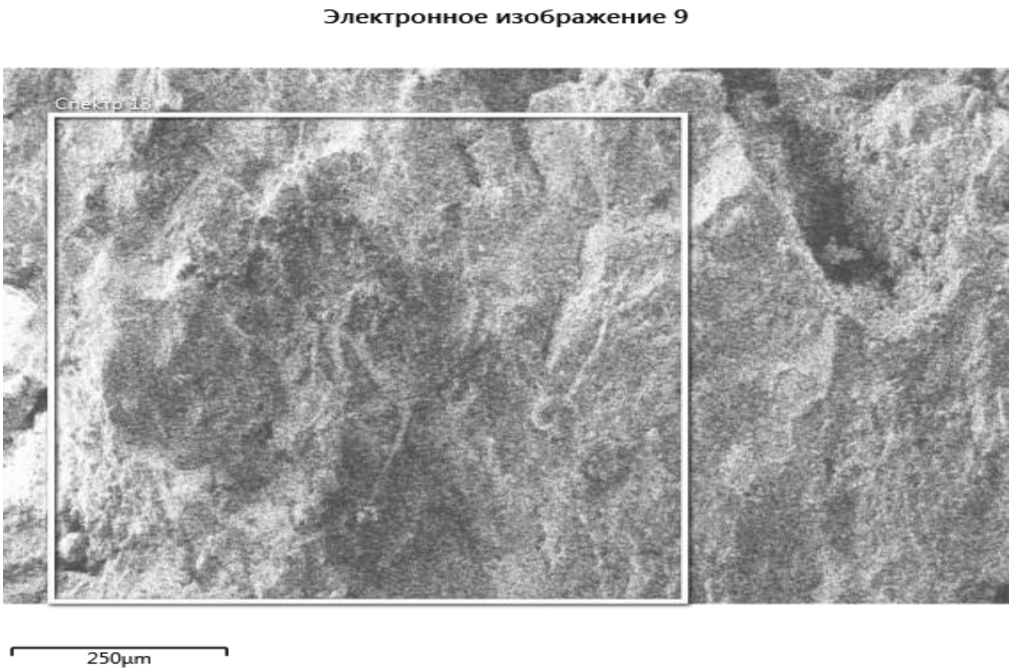


Figure 2. Micrograph of sulfur concrete.

CONCLUSION

The addition of modified sulfur to the concrete composition significantly increased the physical and chemical properties of the concrete. these properties are important for the widespread use of seroconcrete in the construction industry.

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