Soundproofing materials in construction using polymer composites

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Abstract. Today, obtaining products for recycling of polymer materials is of great interest, including for the construction industry. At the same time, not only new materials are created with the specified performance characteristics, but also the environmental problem is solved, nature is preserved and natural resources are saved. In this paper, it is proposed to use a fabric cord of used tires as a component of soundproofing material. Various types of latex were used as a binder: acrylic, natural, and styrene-butadiene. It was found that all the obtained composites have soundproofing properties. The best soundproofing properties are found in a material containing styrene-butadiene latex. Thus, it is shown that materials based on latex of various nature and textile products of tire processing can be used for soundproofing materials in the construction industry.

1. Introduction

Currently, polymer materials are increasingly being introduced into various industries. One of the main consumers of polymer composite materials is the construction industry [1]. Such an active introduction of polymer materials into the construction industry is due to the fact that by introducing various fillers and modifiers into the polymer matrix, it is possible to give composites the required performance properties, varying each time in accordance with narrowly directed requirements [3-4].

Today, obtaining products for recycling of polymer materials is of great interest, including for the construction industry. At the same time, we not only create new materials with the specified performance characteristics, but also solve the environmental problem. Today, the issue of recycling car tires is particularly acute [5]. For example, every year an incredibly huge amount of used tires is sent to landfills. In Europe, about 9 million tons of tires are sent for write-off every year, and in the United States for 2019, the number of worn tires exceeded 3.9 million tons. And if rubber tires are processed, for example, into rubber crumb, then the fabric cord, which is carefully and not without problems separated from rubber and metal, does not have a large-scale application, which to a greater extent worsens the economic situation, in terms of profitability. It is necessary to search for possibilities of using fabric cord [6].

That is why the recycling of tires for use in the construction industry is of interest, in particular, for the production of soundproofing screens [7].
2. Materials and methods

2.1. Materials

For making compositions, components such as binders, fillers, and plasticizers are necessary. Natural, styrene-butadiene and acrylic latex, bituminous emulsion, shungite filler, C3 plasticizers and neonol were used to create a soundproofing material.

Natural latex is obtained by coagulation from the milky juice of Brazilian hevea with the addition of acetic or formic acids. The resulting gel is washed with water and sheets are rolled on rollers, then they are dried [8].

Acrylic latexes include pure acrylic and acrylic-styrene copolymers. The final characteristics of latex can be adjusted during production due to the excellent copolymerization of acrylic and methacrylic esters.

The range of applications of such latexes is very wide, ranging from soft and pressure-sensitive paints or other coatings, ending with the reinforcement of non-woven materials.

Crosslinking is possible under various conditions: at high temperatures, using UV rays, or other options. Products using acrylic dispersions can withstand harsh weather conditions, temperature changes, etc. Dispersions can have different types: paste, foam, spray solution [9].

Styrene-butadiene latexes are general-purpose latexes that replace natural latex in the tire industry, for example, for impregnating the cord [10].

Styrene-butadiene latexes are resistant to storage, dilution, and mechanical stress, this is due to the high content of emulsifier and stabilizer and the small particle size of such latexes. High viscosity is determined by the small size of the particles and their large number.

Crystals of crushed, finely ground shungite have a high level of adhesion, as they have well-defined bipolar properties and are soluble in almost all organic and inorganic substances. In addition, shungite has a wide range of bactericidal properties. Its properties are determined by the nanostructure and composition of its constituent elements: shungite carbon is evenly distributed in a silicate framework of fine quartz crystals, which is confirmed by studies of ultrathin shungite sections by transmission electron microscopy and scanning electron microscopy in absorbed and backscattered electrons [11].

Fast-, medium- and slow-disintegrating emulsions are obtained by adjusting the concentration of the emulsifier. In order to obtain a superstable emulsion, a large amount of emulsifier must be added. Bituminous emulsions, in contrast to bitumen, have a lower viscosity at indoor temperature, which promotes penetration into smaller pores, and they have a high adhesive ability to surfaces of different structures [12].

Plasticizers must be well compatible with the polymer, have low volatility, be resistant to extraction from the polymer by liquid media, be chemically inert, and have no smell [13]. Plasticizer C3 has high plasticizing properties and an effective water-reducing effect, also increases the strength, water resistance, reduces the time and intensity of vibration, and reduces the temperature of isothermal heating [14]. Neonol is a white oily liquid. It has a melting point of 1°C. It is soluble in water, methanol, xylene, and insoluble in kerosene. The specific viscosity is 240 units at a temperature of 25°C. The specific percentage of water content is 0.5%. The product flash point is 94°C.

2.2. Methods

As the developed composite material will be used in the construction industry as a soundproofing material, it is necessary that this composite has good soundproofing properties. In addition, when creating a composite, a high-quality impregnation of fabric cord and shungite with elastomer emulsions plays an important role. The wetting edge angle was measured using the LC-1 goniometer, which measures the edge angle using the lying drop method. The angle was determined based on the description of the shape of the drop contour using the Laplace equation and the tangent method. Today, there are technologies that allow recording the image of a drop and, with the help of programs, get all the necessary data. This is the modern goniometer used for measuring the edge angle [15]. The soundproofing prop-
erties of the material are equally important. To measure the noise level by an objective method, a noise meter device was used, in which noise is perceived using a broadband microphone that converts sound vibrations into electrical ones.

Conducting all the above tests of the resulting composite material is a prerequisite for analyzing the performance properties of PCM, which will be used in the construction industry as a finishing soundproofing material.

3. Results

Three samples were prepared for research.

Sample №1
To prepare the first sample acrylic latex, cord fiber, shungite and neonol were taken.
At first, acrylic latex was mixed with neonol and shungite. Then, cord fiber was impregnated with the resulting mixture. The resulting material was dried.

Sample №2
For the preparation of the second sample natural latex, cord fiber, crumb rubber, shungite and bitumen emulsion were taken.
Initially, bituminous emulsion, shungite and natural latex were mixed. After that cord fiber was impregnated with the mixture. Then the impregnated fiber was mixed with a rubber crumb on the rollers. The resulting material was dried.

Sample №3
For the preparation of the third sample styrene-butadiene latex, cord fiber, shungite, bitumen emulsion and plasticizer-C3 were taken.
Initially, styrene-butadiene rubber, bituminous emulsion, shungite and plasticizer were mixed. Then cord fiber was impregnated with the mixture. The resulting material was dried.

In the course of research, it was necessary to find out the value of the edge angle of wetting latex mixed with shungite. Shungite is fine; the degree of grinding is 0.05 microns. To determine the required amount of shungite, a calculation was performed, which showed that it is necessary to enter no more than 25 mass parts of shungite into latex in relation to the content of rubber in this latex. For the transition from volume to mass, we used the density of latex, which depends on its concentration. The density of the rubber phase is 914 kg/m³, the dispersion medium – sulfur – 1020 kg/m³. Based on this, the density of 1000 kg/m was conditionally accepted. The volume of latex is the same – 10 ml.

After calculating the required amount of shungite, mixtures were prepared and the edge angle was measured (table 1).

| Experience number | Type of mixture          | Natural latex + shungite | Styrene-butadiene + shungite | Acrylic latex + shungite |
|-------------------|--------------------------|--------------------------|------------------------------|--------------------------|
| 1                 | 128.702                  | 124.018                  | 161.050                      |
| 2                 | 112.034                  | 115.062                  | 154.621                      |
| 3                 | 127.213                  | 122.765                  | 152.325                      |
| 4                 | 115.342                  | 121.622                  | 149.023                      |
| 5                 | 126.669                  | 111.284                  | 157.902                      |
| 6                 | 124.645                  | 111.940                  | 149.303                      |
| 7                 | 126.948                  | 129.822                  | 148.337                      |
| 8                 | 122.341                  | 111.093                  | 150.740                      |
| 9                 | 126.732                  | 128.782                  | 151.049                      |
| 10                | 122.264                  | 126.806                  | 140.210                      |
| Average value     | 121.289                  | 120.319                  | 151.456                      |
The results of table 1 show that the edge angle is smaller in a mixture of styrene-butadiene latex with shungite. This is explained by the fact that shungite particles have a diphilic nature and have a negative charge, which allows good distribution in the volume of latex, but the negative charge prevents good wettability with viscose. We also see that the values of the edge angle of pure latex are lower than the values of the edge angle of mixtures. The decrease in wettability is explained by an increase in viscosity.

As the wetting angle is the lowest for a mixture of styrene-butadiene latex with shungite, further studies were conducted with this mixture.

Next, it was necessary to determine the optimal amount of shungite, in mass fractions, which should be added to improve the properties of the material, but, at the same time, avoid a large decrease in wettability and excessive viscosity (figure 1).

![Figure 1.](image)

Amount of shungite in 10 ml, BS latex, m.h.

From these data, we see that with increasing number of injected shungite the value of the contact wetting angle grows, which is associated with an increase in the difference of charges when the number of shungite grows and an increase in viscosity of the mixture.

However, the obtained values show that the wettability of the latex and shungite mixture is too low. As in tire factories automobile fabric cord is necessarily impregnated with a compound that increases the adhesion to the rubber, cord regenerate contains this composition. Therefore, we impregnated the viscose fabric with styrene-butadiene latex. Butadiene-styrene latex, is a part of the impregnation composition, and can be used in our experiment for a closer assessment of the wetting of the cord regenerate. After impregnation, the edge angle was measured (table 2).

| Experience number | BS latex | BS latex + shungite |
|------------------|----------|---------------------|
| 1                | 60.731   | 69.209              |
| 2                | 47.747   | 51.236              |
| 3                | 50.234   | 60.527              |
| 4                | 50.865   | 56.197              |
| Experience number | BS latex | BS latex + shungite |
|-------------------|----------|---------------------|
| 5                 | 46.781   | 69.818              |
| 6                 | 54.121   | 58.890              |
| 7                 | 57.977   | 57.332              |
| 8                 | 47.131   | 61.130              |
| 9                 | 48.029   | 49.674              |
| 10                | 47.105   | 50.870              |
| Average value     | 51.072   | 58.488              |

Based on the obtained results, we can see that the values of the edge angle decreased almost twice, compared to the values when measuring non-impregnated fabric, and for pure latex, and for the mixture, which is associated with an increase in affinity.

The use of an objective noise meter allowed determining approximate values of noise volume levels, which is due to the limited frequency response characteristics. When measuring constant or stationary noise, noise levels were measured for 10 minutes. During this time, several readings of the device arrow were taken. Then the maximum and minimum values were selected from the found values, which were used to calculate the average noise level.

In the course of conducting a research of the acoustic properties of the manufactured material, the following results were obtained, shown in figure 2.

![Figure 2. Sound pressure level versus frequency.](image)

As we can see, all samples have soundproofing properties, and sample №3 has the best soundproofing characteristics.

4. Discussion

Research showed that in order to give the necessary properties without creating significant difficulties during processing, 25 mass parts of shungite must be added to the composite material. It was found that the mixture of shungite and styrene-butadiene latex has better wettability compared to mixtures based on acrylic and natural latex.

The best soundproofing properties are found in a material containing styrene-butadiene latex.
5. Summary
Thus, it is shown that materials based on latex of various nature and textile products of tire processing can be used for soundproofing materials in the construction industry.

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