Thermal insulation materials of different structures producing on the basis of flax boon

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Abstract. The article considers options for obtaining building materials based on flax boon. Infrared spectroscopy data of organic aggregate (flax boon) are presented, and physicochemical processes and structure formation in heat-insulating materials on various types of binder are studied. Technological ability of aerated concrete production based on flax boon and granulated goods are determined.

1. Introduction

The use of secondary resources in the production of building materials is a significant reserve for efficiency improvement of construction. There is agricultural waste among such resources: flax boons, hemp, jute, ambari, stalks of cotton, rice straw, etc.

Studies on the use of flax processing waste products as raw materials for the building materials production have been conducted since the beginning of the 20th century. Obtaining construction materials based on flax boon is mainly carried out using the following technologies: the manufacture of products based on flax boon without an astringent, the drawback of this method is the high energy intensity; the production of plates from the flax boon with the use of phenol-formaldehyde and urea-formaldehyde resins as binders, the disadvantage is the release of harmful substances into the environment. Nowadays, building materials based on plant raw materials (peat placers, reeds, etc.) cannot be attributed to perspective insulating materials because of their flammability, insufficient water and bio resistance. As a rule, they are used only in temporary buildings and structures.

The analysis of technical and patent literature did not reveal the compositions and parameters for the production of heat insulation materials based on flax boon and complex binders, cellular concrete on vegetable aggregates – flax boon, and granular materials on the same aggregate.

The timeliness of the work is due to the fact that heat-insulating materials based on vegetable raw materials are characterized by high thermo-technical indicators, besides, from the ecological point of view, the problem of recycling agricultural waste is solving and at the same time it becomes possible to obtain environmentally friendly building materials. In addition, the waste products use of flax processing in the manufacture of thermal insulation materials will reduce their cost through the use of incidentally received, not currently in use, raw materials.

Based on the problem analysis of obtaining heat insulation products on the basis of flax boon, the goal and tasks of the work are formulated. The goal of the work is to obtain heat-insulating materials of various structures on the basis of flax boon, mineral and organic binders. In order to achieve the goal it is necessary to solve the following tasks:

- Determine the composition and properties of organic aggregate – flax boon.

- Select the optimal ratios of flax boon and binders in the preparation of pressed, porous and granular materials.
- Optimize the composition and technological parameters of obtaining heat-insulating materials of various structures on the basis of flax boon.

2. Methods and materials

The composition and properties of the organic aggregate were determined in our research. Flax boon is a by-product from flax processing and one of the most common agricultural wastes. Flax is an annual plant whose fiber length, depending on the species and growth conditions, can be 4 mm or more with a width of 0.01 ... 0.03 mm. For flax fibers, the following structural features are characteristic: sharpened ends, narrow threadlike channel (cell cavity), reaching the ends of the cell, strongly and uniformly thickened shells, slit-like simple pores. The stems of flax during the separation of fiber in the breaking and scutching processes are destroyed, and the falling lignified parts form a flax boon [1,2]. Dimensions of these particles range from 1 to 10 mm in length, and from 0.3 to 1 mm in thickness. The main portion of flax production and flax processing (about 70%) falls on the Central and West Siberian regions. In Siberia flax-scutching plants are located in the Omsk, Novosibirsk regions, Altai Territory.

The material composition of the initial component – flax boon, was studied by infrared spectroscopy using the "Scimitar FTS 2000" infrared spectrometer (Figure 1). To study the IR spectra of flax boon, solid samples were prepared by pressing tablets with KBr. Flax boon was previously dried at a temperature of 500C and ground in an agate mortar. The amount of the starting material is 1 mg per 6 KBr. Next, a tablet was prepared, and the spectrum of the substance was recorded.

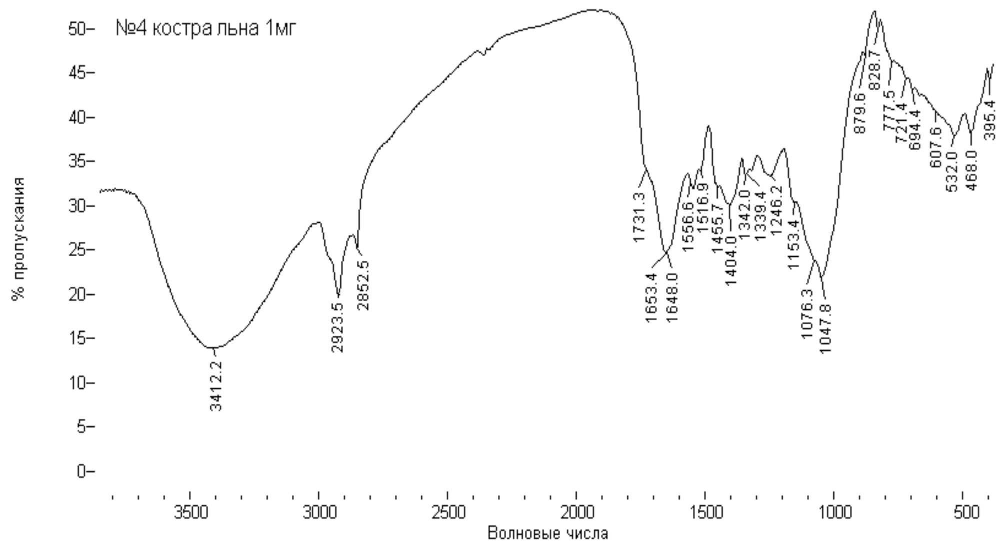


Figure 1. IR spectrum of flax boon. Y is the transmission%, and X is the wave number.

IR spectrum of flax boon shows the main fluctuations in the range of 3500-2800 sm-1 and 1750-1050 sm-1. The absorption band is wide and strong in the range of 3500-3100 sm-1 with a maximum at 3412 sm-1, which is associated with valence vibrations of hydroxyl groups' various types. The bands in the range of 3000-2800 sm-1 refer to the stretching vibrations of (CH) methyl and methylene groups, the deformation vibrations of these groups are located in the interval 1460-1360 sm-1. The 1923 sm-1 band is common to vibrations of methoxyl bound to the aromatic nucleus and stretching vibrations of CH in the CH2 and CH3 groups. The band 1852 sm-1 corresponds to stretching vibrations of C-H bonds in methoxyl groups.

An increased content of lignin in flax boon was found up to 44-46%, confirmed by absorption bands on the IR spectrum at 1653 sm-1, as well as bands in the range of 1540-1510 sm-1, common to vibrations of rings [3]. An intense structured band (max 1048 sm-1) is observed in the range of 1250-1050 sm-1. Deformation vibrations of (OH) and (C-O) groups, as well as stretching vibrations of (C-OH) groups, which absorption bands overlap, become apparent here. The hydroxyl groups cause background absorption in the range of 700-500 sm-1.

Cellulose and lignin, which make up the bulk of the flax boon's cell walls and determine their mechanical strength, are sufficiently persistent substances and do not exert any adverse effect on the hardening process of the binder. The hemicellulosic part of the flax boon is a complex organic substance (polysaccharides) capable of hydrolyzing and passing into water-soluble sugars in an alkaline medium (which is a cement slurry covering an organic aggregate). Water-soluble sugars are a "cement poison", i.e. substances that prevent the hardening of clinker minerals. However, the content of hemicellulose in flax boon is not large (up to 11%).

Flax boon has bulk density - 110 ... 120 kg/m3, humidity - 15 ... 20%, hygroscopicity - 24..26%. The ignition temperature is 210 ... 220 ° C, the thermal conductivity in the dry state is 0.037 ... 0.041W / (m°C). Flax boon in dumps has a moisture content of 12-30%. There is a stabilization of moisture for 3-5 days at room temperature, as its drying decreases its bulk density [4].

When determining the composition and properties of the aggregate, it is noted that the parameters for obtaining building materials based on flax boon differ from materials based on wood waste due to the difference in their properties. Such specific properties of organic fillers, such as moisture deformations, pronounced anisotropy, elasticity, are not significantly manifested in flax boon, in comparison with wood.

3. Experiment

The selection of flax boons' optimal ratios and binders for obtaining pressed, porous and granular materials was made.

In the composition of pressed and granulated heat-insulating materials, the content of the flax boon reaches 65-70%. The components of different structure materials on the basis of flax boon by functional designation are divided by the author of this work into the following groups: 1- organic materials, which serve as a binder, include synthetic latex, polyvinyl acetate dispersion; 2 - materials acting as a mineralizer, and with a higher dosage as a mineral binder, this function is performed by liquid glass; 3 - materials that fulfill the role of binders, Portland cement refers to them.

As the quality rating of the first group materials the indices of strength, adhesion with organic aggregate are served. The technical effect of the second group additives is determined by the neutralizing effect and the number of them in the flax boon mixture during the production of maximum strength materials on the basis of binders. As the quality rating of materials that perform the role of binders such indicators as, setting and hardening time, hydraulic activity in mixture with flax fiber, strength are served [5].

For the studies, a complex binder-sodium liquid glass together with butadiene-styrene latex was used. The ratio of the organic part to the inorganic in the complex binder was established. Samples based on an organomineral binder with a component ratio of 1: (0.15-0.25) have the lowest average density of 286 kg/m^3 and a thermal conductivity of 0.057 W/m ° C. At a ratio of the inorganic part to the organic one: (0.35-0.5), the samples are characterized by high compressive and bending strengths of 0.78 and 1.25 MPa. However, an increase in the organic binder content leads to an increase in the cost of material. The ratio of 1: 0.15 inorganic parts to organic is taken as a basis for the selection of the pressed heat-insulating products' composition [4].

The optimum content of the complex binder with respect to the flax boon 1.15: 1 (parts by weight) was established. The optimum composition of the feed mixture for pressed materials was determined, including, in mass%: flax boon fractions 5 mm - 23-25; flax boon fractions 10 mm - 13-15; liquid glass - 35-40; butadiene-styrene latex - 5-6; water - 17-19 [5].

The physicochemical processes and structure formation in the aggregate materials on the complex binder were studied. The study of the processes occurring in the contact zone during the hardening of binders and organic aggregate was carried out according to IR spectra. In order to study the IR spectra of flax boons based on liquid glass and latex, samples were prepared by pressing. The materials were previously dried at a temperature of 65°C, then ground in an agate mortar. The amount of the starting material is 1 mg per 6 g of KBr. Next, a tablet was prepared, and the substance spectrum was recorded.

The IR absorption spectrum of flax boons with the addition of liquid glass (Figure 2) contains an intense band at 1038 sm-1, corresponding to the Si-O-group's stretching vibrations. The absorption bands at 794; 779 and 460 sm-1 belong to the Si-O group. As a result of the interaction, the intensity of the 1650 sm-1 band decreased and a number of bands appeared in the interval of 1658-1565 sm-1.

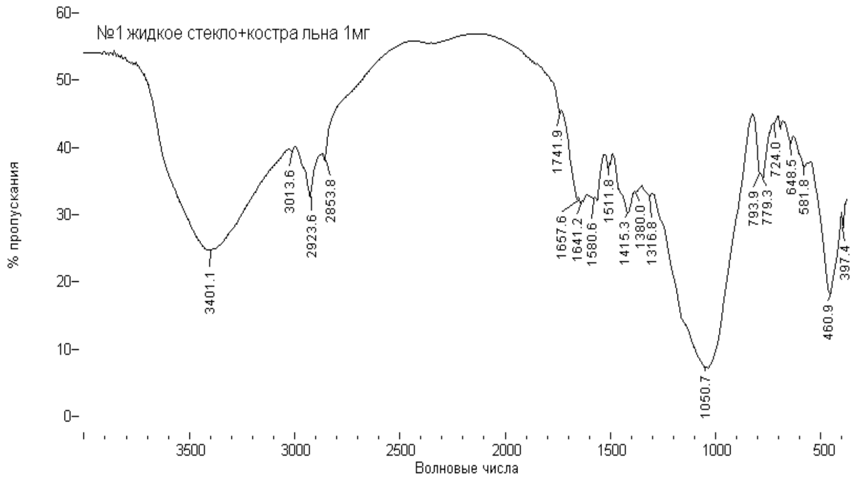


Figure 2. IR spectrum of flax boon samples on the basis of liquid glass. Y is the transmission%, and X is the wave number.

IR absorption spectrum of flax boon with the addition of butadiene-styrene latex, the absorption bands correspond at 1512; 1455; 972; 914; 760 and 698 sm-1 is shown in Figure 3.7. The valent vibrations (C = O) at 1742-1712 sm-1 are greatly enhanced in comparison with the spectrum of the flax boon based on liquid glass (Figure 3).

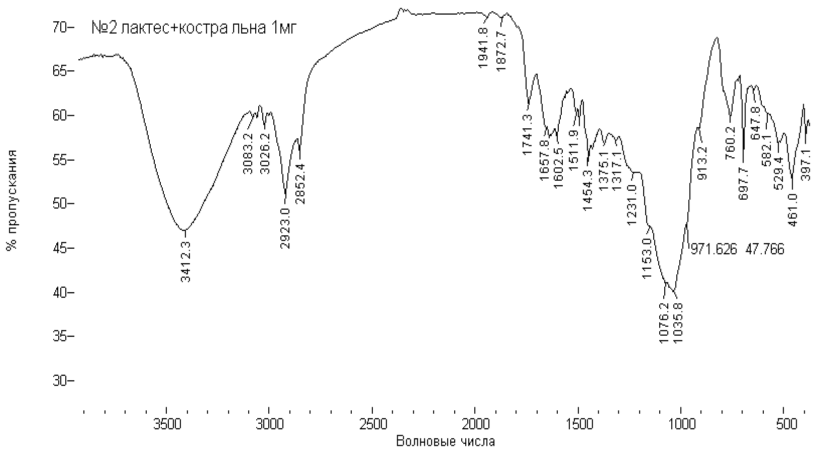
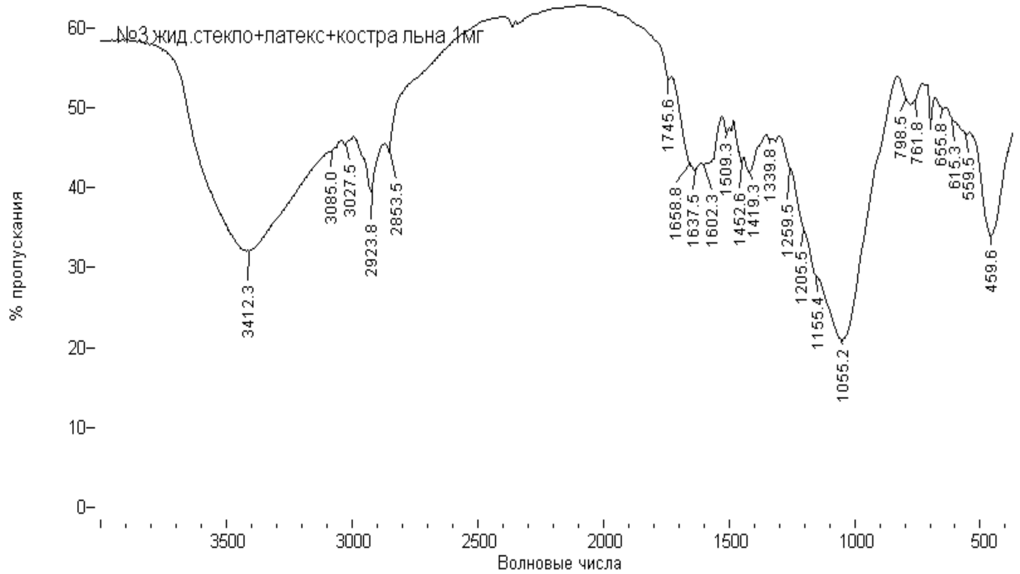


Figure 3. IR spectrum of flax boon based on butadiene-styrene latex. Y is the transmission %, and X is the wave number.

A number of bands are observed in the interval 3085-3027 sm-1 in the IR spectrum of flax boon, based on a complex binder (Figure 4 (a)). A number of bands appeared in the interval 1637-1509 sm-1, with the band at 1745 sm-1 shifted to the high-energy region as compared to the spectrum of the flax boon (Figure 1). The absorption bands at 779 and 460 sm-1 refer to the Si-O-group. The absorption band at 699 sm-1 corresponds to butadiene-styrene latex. The bands 1600 and 1510 sm-1 refer to the vibrations (C = C) of the aromatic ring of lignin contained in the flax boon. Valence vibrations of (C-H): CH -, CH2 -, CH3 - groups appear in the range of 3000 - 2800 sm-1.

(a)



(b)

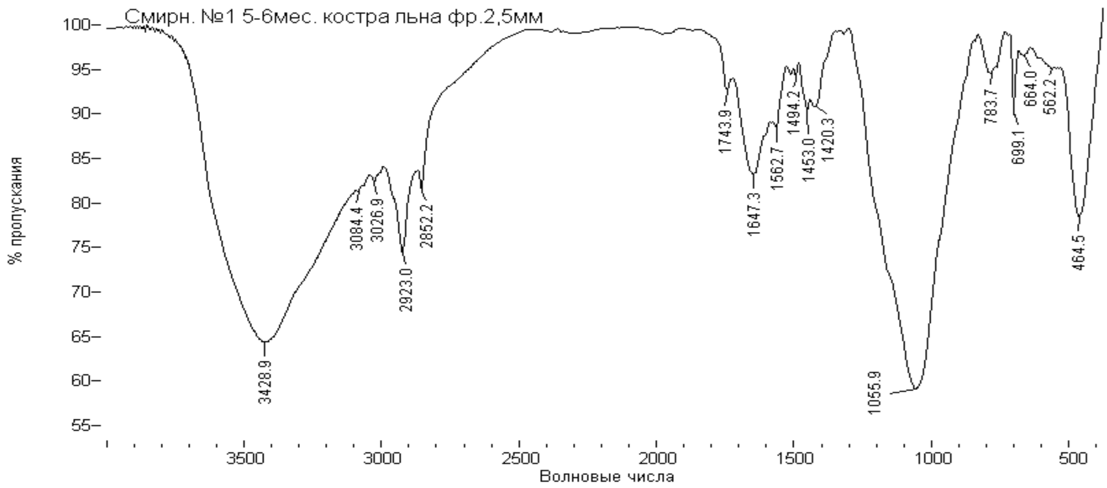


Figure 4. IR spectrum of flax boon based on a complex binder: (a) - a sample at the age of 3 days, (b) – a sample stored for 6 months. Y is the transmission%, and X is the wave number.

The bands in the range of 1743-1492 sm-1 characteristic for the deformation vibrations of the lignin rings indicate the interaction of the flax boon with the complex binder. Moreover, this interaction increases with the age increment of the samples (Figure 4 (b)). The appearance of these bands is associated with the adsorption action of the complex binder.

As a research result of obtaining porous building materials on the basis of flax boon, the composition and technological parameters of obtaining non-autoclaved aerated concrete based on it have been developed [6]. The flax boon fractions use of less than 2.5 mm in the composition of raw mixtures for the aerated concrete production allows replacing quartz sand completely. The ratio of the organic aggregate to the binder is 1: 1.25 and 1: 1.5 (parts by weight). The swelling of the flax boon is 2% and this partially compensates for shrinkage of aerated concrete, which is 3-3.5%. Flax boon has a significant effect on the processes occurring in the aerated concrete mixture during the maturing stage. The need to treat flax boon with a solution of liquid glass is determined. The optimal composition of aerated concrete on the flax boon basis was determined by the method of experiment and data processing mathematical planning. The area corresponding to the content of flax boon 130-140 kg, with a gas developing agent content of 0.79-0.80 and a water-hard ratio of 0.8-0.95 is optimum. The porous materials based on flax boon have an average density of 300-400 kg / m3, compressive strength of 0.88-1.09 MPa, thermal conductivity of 0.074-0.085 W / (m0C).

For the production of granulated building materials, the fraction's flax boon of no more than 2.5 mm and a bulk density of 125-130 kg / m3 were used. In order to achieve the optimum values of bulk density, strength and granulometric composition of granular materials, compositions with the use of mineral (Portland cement, liquid glass) and organic binders (PVA, latex) were prepared. The regrounded flax boon shows a good ability for pelletizing, the fractional yield of 10-15 mm reaches 81%, and therefore this fraction is optimal and characterizes the granulation of the investigated compositions. Maximum degree of granulation is shown by flax boon on the basis of polyvinyl acetate emulsion and liquid glass, the fractional yield of 10-15 mm is 62% and 81% for granules based on liquid glass with a cement sheath [7].

In the process of granules on a complex binder obtaining, the following sequence of technological operations was used: moistening of the flax boon - adding liquid glass and an aqueous polymer solution (latex or PVA) - granulation - hardening - fractionation. Granules with the use of mineral binders were prepared according to the 2nd technological method: moistening of the flax boon - adding liquid glass - granulation - powdering with cement powder - hardening - fractionation.

It is established that when obtaining a filler of a certain granulometric composition, the granulation process is influenced not only by the material indices (mixture composition, humidity), but also by technological parameters such as the granulation time and the poppet tilt angle of the granulator.

4. Conclusions

We developed technologies for producing pressed, porous and granular materials based on flax boon.
The optimum composition of the raw mix for pressed materials was determined, including, in mass %: flax boon fraction 5 mm - 23-25; flax boon fraction 10 mm - 13-15; liquid glass - 35-40; butadiene-styrene latex - 5-6; water is 17-19.

The composition of the raw mix for the non-autoclaved aerated concrete production is determined, including the following components (%, mass): Portland cement - 27-35; flax boon - 22-25; quartz sand - 13-15; ground lime - 2,7-3,3; aluminum powder - 0,043-0,05; water - the rest.

The composition of the raw mix for granular materials' preparation on a complex binder, in mass %: flax boon fraction less than 2.5 mm - 27-30; sodium liquid glass - 23-25; butadiene styrene latex - 15-20; water is 25-35. The composition of mineral binders, in mass %: flax boon fraction less than 2.5 mm - 25-27; sodium liquid glass - 25-27; Portland cement PC400-D20 - 17-19; water is 27-33.

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