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DEVELOPMENT OF A METHOD FOR FIRE-RESISTANT FINISHING OF NON-WOVEN MATERIAL USING A PHOSPHORUS-CONTAINING COMPOSITION

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The aim of the study is to obtain a non-woven material with flame retardant properties. The conditions of the process of fire-retardant finishing were as follows: an aqueous solution of preparations of various concentrations was applied by spraying onto the surface of the material, then drying was carried out and heat treatment on a thermal press. According to GOST R 50810-95, non-woven material made from flax and wool fibers, treated with a composition based on an aqueous solution of sodium phosphate and guanidine hydrochloride, is classified as a flame-retardant material. Also, tests for toxic and skin-irritating effects of non-woven material treated with the proposed composition showed its safety for human health.

Keywords: non-woven material, sodium phosphate (SP), polyvinyl alcohol (PVA), guanidine hydrochloride (GHC).

БЕЙМАТА МАТЕРИАЛЫН ФОСФОРЛЫ КОМПОЗИЦИЯМЕН ОТҚА ТӨЗІМДІ ӨҢДЕУ ӘДІСІН ӘЗІРЛЕУ

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Зерттеудің мақсаты - жалынға төзімді беймата алу. Өртке төзімді өңдеу процесінің шарттары мынандай болды: әртүрлі концентрациядағы препараттардың сулы ерітіндісі материалдың бетіне бүрку арқылы жағылды, содан кейін кептіру термиялық өңдеу термопрессте жүргізілді. ГОСТ Р 50810-95 бойынша фосфор қышқылды натрий мен гуанидин гидрохлоридінің сулы ерітіндісі негізіндегі композициямен өңделген зығыр және жүн талшықтары бейматасы отқа төзімді материалға жататыны анықталды. Сондай-ақ токсикологиялық және тері тітіркендіргіштік әсерге жүргізілген сынақтар ұсынылған құрамның адам денсаулығына қауіпсіздігін көрсетті.

Негізгі сөздер: беймата, фосфорқышқылды натрий (ФҚН), поливинил спирті (ПВС), гуанидин гидрохлориді (ГГХ).

РАЗРАБОТКА СПОСОБА ОГНЕЗАЩИТНОЙ ОТДЕЛКИ НЕТКАНОГО МАТЕРИАЛА С ПРИМЕНЕНИЕМ ФОСФОРСОДЕРЖАЩЕЙ КОМПОЗИЦИИ

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Целью данной работы является получение нетканого материала с огнезащитными свойствами. Условия процесса огнезащитной отделки нетканого материала были следую-щими: водный раствор препаратов различной концентрации наносили методом распыления на поверхность материала, последующей сушкой и термообработкой на термопрессе. Согласно ГОСТ Р 50810-95 нетканый материал из волокон льна и шерсти, обработанным составом на основе водного раствора фосфорнокислого натрия и гуанидин гидрохлорида, классифицируется как трудновоспламеняемый

материал. Также результаты экспериментов по определению токсичности и кожнораздражающего действия предлагаемого состава показали его безопасность для здоровья человека.

Ключевые слова: нетканый материал, фосфорнокислый натрий (ФКН), поливиниловый спирт (ПВС), гуанидин гидрохлорид (ГГХ).

Introduction

Rationale for the choice of topic, purpose and objectives

Resistant textile materials of various nature has become increasingly important. This is due to the fact that they are a serious source of danger during fires, ignite easily, contribute to the spread of flames and, when burned, emit large amounts of smoke and toxic gases. In this regard, in many foreign countries the use of products made of flammable materials is prohibited by law.

One of the most important tasks in the textile industry is the development of effective, environmentally friendly flame retardants with high performance. The development of fire-resistant textile materials on a large industrial scale remains unrealized, due to the lack of efficiency of known technical solutions. The problem covers the issues of flame retardant interaction with fibrous materials, including technological aspects of fire protection, environmental requirements, issues of durability and material compliance with fire safety regulations.

Thus, the development of a technology for modifying textile materials with stable flame retardant properties using relatively inexpensive and environmentally friendly chemicals will increase the economic efficiency of the use of fibrous materials in various fields .

In this work, the focus is on the processing of nonwovens at the stage of emulsification or after forming the canvas by spraying with a solution of flame retardants. Non-woven materials with fire-resistant properties are used in construction as insulation materials. There is also information on the use of non-woven fabrics with fire-resistant properties as floor coverings in public institutions and in everyday life [1-5]. To reduce the fire hazard of textile materials, flame retardants of various compositions are used: halogen- and phosphorus-containing compounds, ammonium polyphosphates, and chlorine-containing compounds [6].

The aim of the study is to develop a composition and method for producing a fire-retardant non-woven material based on sodium phosphate (SP), polyvinyl alcohol (PVA) and guanidine hydrochloride (GHC) .

To achieve this goal, the following tasks were solved:

1. The possibility of obtaining effective flame retardant compositions for nonwoven material using relatively inexpensive and environmentally friendly chemicals has been established.

2. The composition of the flame retardant composition for non-woven material has been developed.

3. The flame retardant properties of the non-woven material processed in the new way were studied using various research methods.

Materials and Research Methods

Objects of study : non-woven material from linen and wool fibers, as well as chemicals (sodium phosphate (SP), polyvinyl alcohol (PVA) and guanidine hydrochloride (GHC)).

Conditions for the process of fire-retardant finishing of non-woven material: an aqueous solution of preparations of various concentrations was applied by spraying onto the surface of the material, followed by drying and heat treatment on a thermal press .

When performing experiments, complex research methods were used. The combustion resistance of the material was determined in accordance with the requirements of the GOST R 50810-95 standard [7]. The study of the surface morphology of textile fibers was carried out using a JSM- 6490LA scanning electron microscope. The air permeability of the fabric was determined on an MT-160 instrument [8].

Main part

Results and their discussion

The aim of the research work is to obtain a nonwoven material with flame retardant properties .

As components for preparing the flame retardant composition. Based on the preliminary experiment, the concentration of sodium phosphate was varied within 10-25 g/l, polyvinyl alcohol - 5-30 g/l and guanidine hydrochloride - 5-10 g/l (table 1).

Table 1 - Composition of compositions for imparting fire resistance properties to nonwoven material

Compound No.	Sodium phosphate, (g/l)	Polyvinyl alcohol, (g/l)	Guanidine hydrochloride, (g/l)
1	10	5	-
2	10	10	-
3	15	5	-
4	15	10	-
5	25	5	-
6	20	20	-
7	20	30	-
8	25	-	10
9	25	-	5
10	12,5	-	10
11	12,5	-	5

To process the material, an aqueous solution of the composition of various concentrations was applied to the surface of a canvas of linen and wool fibers by spraying, followed by drying and heat treatment at 180 °C for 1 min on a thermal press.

An untreated sample of nonwoven material, when tested for flammability with an ignition time of 15 seconds, burns completely in 45 seconds. A sample treated with SP and polyvinyl alcohol, when brought to a flame, ignites, when introduced, it slowly ignites and chars, with the release of gray smoke. For a sample treated with a composition containing sodium phosphate and guanidine hypochlorite when tested for fire resistance independently e combustion is reduced to zero (Figure 1) [7].

1-sample, raw nonwoven fabric,
2-sample treated with composition: PVA-5 g/l, SP-25 g/l
3-sample treated with composition: GHC-10 g/l, SP-25 g/l

Figure 1 - Samples of nonwoven fabric after fire test

Also, non-woven material was tested for fire resistance in a fire testing laboratory in accordance with the requirements of the GOST R 50810-95 standard at the OVT installation .

Table 2 - Test results for fire retardant performance

No.	Drug concentration			The length of the charred area, mm
	Sodium phosphate, (g/l)	Polyvinyl alcohol, (g/l)	Guanidine hydrochloride, (g/l)	
1	original sample			220
2	10	5	-	180
3	10	10	-	188
4	15	5	-	178
5	15	10	-	175
6	25	5	-	168
7	20	20	-	170
8	20	30	-	175
9	25	-	10	87
10	25	-	5	90
11	12.5	-	10	92
12	12.5	-	5	95

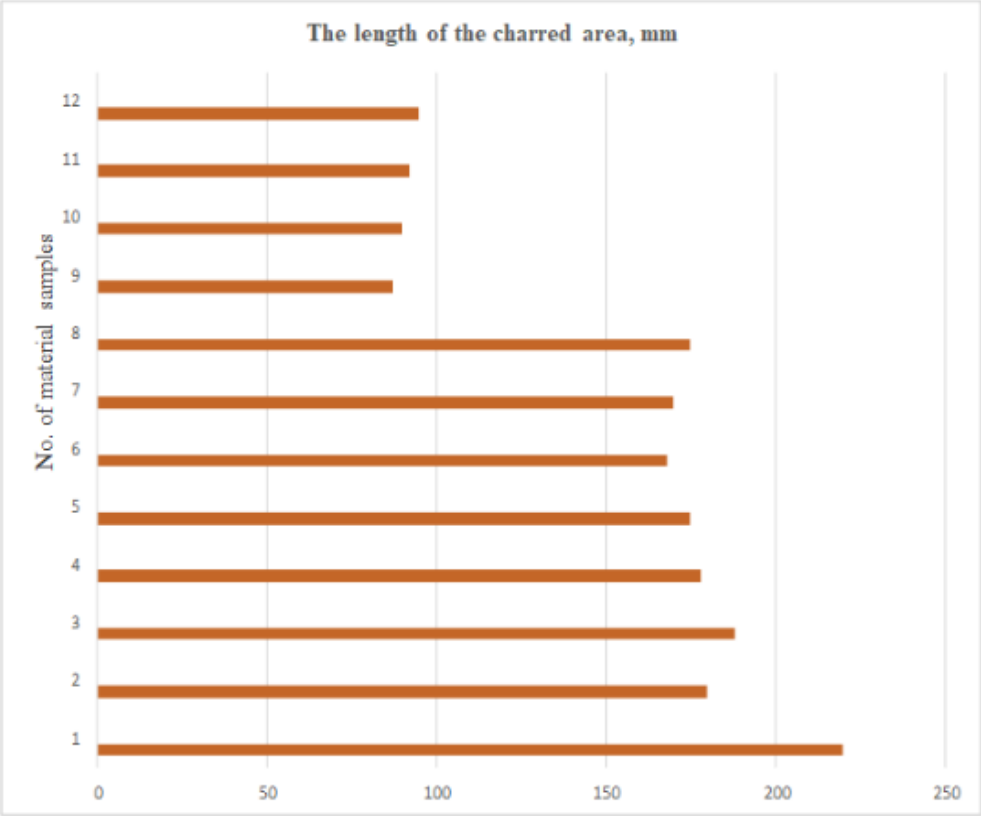


Figure 2 - Dependence of the length of the charred section of the nonwoven material on the composition of the fire-retardant composition (numbering of samples according to table 2)

For specimens treated with a flame retardant composition, with an increase in the concentration of sodium phosphate and GHC in the composition, the length of the charred area decreased from 220 to 87 mm (Tables 2, 3; Figure 2).

Table 3 - Test results for fire resistance of nonwoven fabric

No	Sample	Duration of contact with the flame, sec	Note	Snapshot of material sample after testing
1	source material sample	15	The sample, when brought to the flame of the burner, instantly smolders; when brought into the flame of the burner, it instantly ignites, burns with the release of gray smoke, residual combustion persists until the complete combustion of the sample.	
2	Sample treated with composition: PVA-30 g/l SP - 20 g/l	15	The sample, when brought to the flame of the burner, ignites, when introduced, it lights up, with the release of gray smoke. When removed, afterburning lasts up to 87 seconds. The length of the charred area is 175 mm.	
3	Sample treated with composition: GHC -10 g/l SP - 25 g/l	15	The sample, when brought to the flame of the burner, smolders slightly; when brought into the flame, the sample does not ignite, does not char. Afterburning is reduced to zero. The length of the charred area is less than 90 mm.	

Also, the results of the study carried out in the test fire laboratory showed that the duration of residual combustion when the flame was removed, for the source material - 98 seconds, for the sample treated with SP and polyvinyl alcohol is 87 seconds. This indicator for the material treated with SP and guanidine hydrochloride is reduced to zero (Figure 3).

Thus, it can be concluded that the composition based on sodium phosphate and guanidine hydrochloride provides high flame retardant properties to the nonwoven material. The proposed composition is recommended as a combined composition for emulsifying and fire-retardant finishing of a mixture of fibers, since guanidine hydrochloride provides a decrease in electrification and an increase in the adhesion of non-woven material fibers.

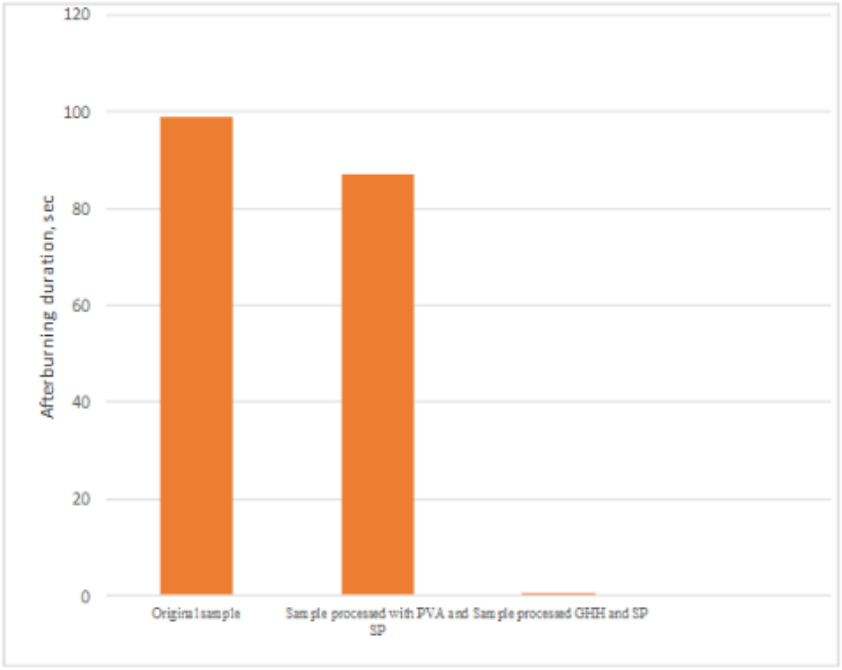
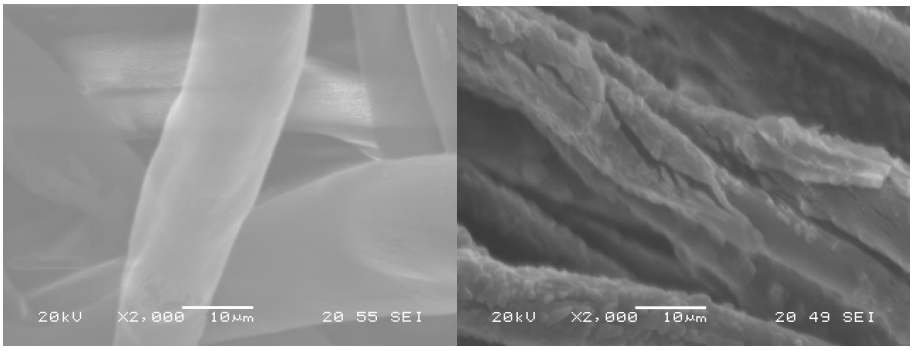


Figure 3 - Duration of afterburning according to GOST R 50810-95

It is known from the literature that the treatment of a material with polymer compositions can lead to a change in its permeability properties. In this regard, the air permeability indicators of the studied samples of nonwoven material were determined. The coefficients of air permeability of the treated samples are 482 - 572 dm^3/m^2 sec., of the original material - 635 dm^3/m^2 sec. The air permeability of the material samples treated with the composition based on sodium phosphate and GHC did not significantly decrease compared to the original sample.

Studies of the morphological features of the untreated and processed material were carried out using an ultra-high resolution scanning electron microscope. According to the results of scanning electron microscopy, a change in the morphological surface of the treated samples was revealed in comparison with untreated materials. Analysis of photographs (Figure 4a) showed that the untreated sample has a smooth surface and a homogeneous structure. It has been established that a polymer layer is formed on the surface of the treated nonwoven material from the composition of SP and guanidine hypochloride (Figure 4b).



a) b)

Figure 4 - Electron microscopic images of nonwoven materials

In addition, the results of experiments to determine the toxicity and skin- irritating effect of the proposed composition showed its safety for human health.

Based on the analysis of the results obtained, the treatment of non-woven material with a composition based on SP, GHC provides a high degree of fire resistance of the treated textile materials.

Conclusions

A composition based on sodium phosphate and guanidine has been developed hydrochloride to impart flame retardant properties to non-wovens. Non-woven material treated with the proposed composition acquires high fire retardant properties.

The air permeability of the material samples treated with the composition based on SP and GHC did not significantly decrease compared to the original sample.

According to the results of scanning electron microscopy, a change in the morphological surface of the treated samples was revealed compared to untreated samples. Analysis of the photographs showed that the untreated sample had a smooth surface and a homogeneous structure. It has been established that a polymer layer is formed on the surface of the treated nonwoven material from the composition of SP and GHC.

The results of experiments to determine the toxicity and skin- irritating effect of the flame retardant composition showed its safety for human health.

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