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DEVELOPMENT OF TWO-LAYER NONWOVEN CANVASES WITH ANTIMICROBIAL PROPERTIES

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Development of nonwoven fabrics (NVF) and underwear made of them, designed for removing and localizing products of dermal respiration, is an urgent task.

These materials must possess good absorbing ability (at least 4g per 1 g of material), as well as to remove moisture, leaving a dry surface in contact with a human body, ensuring comfort when wearing special clothing.

Material's ability to absorb and localize the moisture in the layer, which has no direct contact with the human body, can be achieved through a combination of hydrophilic and hydrophobic layers in the structure of nonwoven fabric.

Based on the requirements to NVF, a stitch-bonding process for manufacturing of non-woven fabric has been selected in which the multi-layered structure of fabric is connected by warp interweaving in one technological process. Fibrous layer, having direct contact with human skin, is composed of hydrophobic fibers, and the second layer - of the hydrophilic ones. The layer is connected with a stitched thread by means of weave knit "tricot". Products of human dermal respiration, due to the high capillarity of the hydrophobic layer, pass freely through it, and due to the difference of surface tension between the layers are absorbed and uniformly distributed in a hydrophilic fibrous layer.

Effectively solving the problems of removing and localizing products of human dermal respiration, multi-layer nonwoven fabric should, at the same time, protect humans from microorganisms.

Polypropylene fiber 0.22 tex with cutting length of 60 mm is selected as the fibrous raw material for the hydrophobic layer; blend of linen and viscose fibers (0.31 tex, 65 mm) 50:50 - for the absorbent layer.

The selected fibers have a high absorption capacity (14.5 g / g for viscose and 13.5 g / g for flax) and sorption of water vapor from the air (27...33 wt% and 19...32 wt%, respectively).

Polyester-viscose yarn 18.5 tex and 12 tex polyester filament was used as a stitching thread.

The surface density of the samples of nonwoven fabric was 160±10 g/m^2. Sewing density along the length - 30 loops/50mm, width - 20 loops /50 mm.

Test results of physical and mechanical properties of the water-absorbing cotton-stitched fabrics showed that water absorption of samples stitched with polyester thread is more than that of polyester-viscose, because the thinner hydrophobic polyester thread creates a sparse network structure and does not compress the fibrous layer. It is optimal to use polyester thread (yarn) 12 tex and polypropylene fiber content of 25% mass.

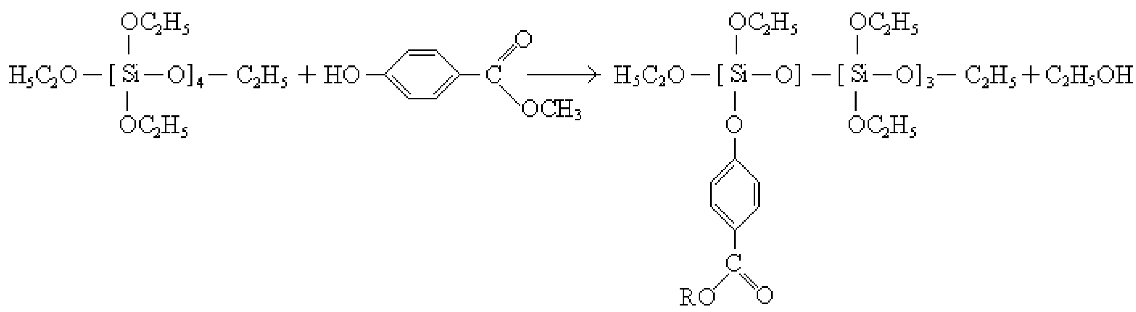
The conducted operational tests of underwear, made from water-absorbing flax-containing stitched fabrics, showed that the presence of flax fiber in the absorbent layer contributes to a more rough and tough material structure. Therefore, during further work for the manufacture of the hydrophilic layer, viscose fiber was applied.

For antimicrobial nonwoven materials modifiers were used - synthesized by us - obtained on the basis of para-hydroxybenzoic acid ester, better known as parabens.

We have used compounds based on methyl and para-hydroxybenzoic acid ester and their synergistic mixtures [1].

Synthesis was carried out under the scheme 1.

Diagram 1.



We studied the effect of the content oligoethoxy (4-propilcarboxyphenyloxy) siloxane (oligomer I) and a mixture of oligomer I with oligoethoxy (4-methylcarboxy-phenyloxy) siloxanes (oligomer II) at a ratio of 4:1 and the conditions of heat treatment for antimicrobial, mechanical and functional properties (water absorption, air permeability, rigidity, abrasion resistance) of the nonwoven fabric.

Biologically active mixture was deposited on the surface of a nonwoven fabric from the side of hydrophobic layer.

Stability of samples of nonwoven fabric to microbial degradation was determined according to GOST 9.060-75.

Data on the influence of nature, the content of the modifier and processing temperatures on the microbiological stability of NVF are presented in Table 1.

The samples are considered to be resistant to microbiological degradation, if the stability factor P is equal to 80 ± 5%.

Table 1

	The content of oligomer I, % mass	Stability factor P, %			
		Temperature for fiber processing, ºC			
		-	115ºC	130ºC	145ºC
Polypropylene fiber	0	57			
	2,5	75	78	79	83
	6,25	76	84	83	78
	10	78	87	84	82
	13,75	77	82	80	78
	The content of the mixture of oligomers I and II (4:1),% mass.				
	2,5	78	81	82	84
	6,25	76	80	79	81
	10	79	78	75	79

Data Analysis (Table 1) shows that the modification of polypropylene fibers (also similarly of polyester) by new oligomers in the amount of 2.5...13.75% wt. allows to obtain nonwoven fabric resistant to microbial destruction.

Heat treatment of modified fibers increases their resistance to the action of microorganisms, since it allows to firmly fix the modifier on the fiber surface.

Increasing the content of the modifier on the fiber has no significant effect on the rate of resistance to microbial degradation, as the antimicrobial agent is allocated in doses due to hydrolysis of chemical bonds when exposed to high humidity created in the space under the clothing. The higher content of modifier in the nonwoven fabric allows it to retain antimicrobial properties for a longer time and to withstand up to 20 launderings and wet treatments. The use of modifiers I and II does not give a pronounced synergistic effect, however simultaneous application of these oligomers enables to compensate for their effects on microorganisms, since for suppression of vital activity of various species of bacteria and fungi different amount of oligomers I and II is needed.

Stability samples of the nonwoven fabric samples to biodeterioration fungi was determined according to GOST 044415-94.

The test results showed that all samples of nonwoven fabric, modified with oligomer I or a blend of oligomers I and II, are resistant to mold fungi.

The effect of treatment by fiber modifiers and heat treatment conditions on physical and mechanical properties of nonwovens has been studied. It has been demonstrated that, compared with the strength of stitched material from unmodified fibers, the strength of nonwoven fabric after processing with modifiers I and II increased 1.1...3.2 times, water absorption increases 1.1...1.46 times, air permeability - 1. 1...1.7 times, the rigidity is reduced by 1.7 times, the stability of the nonwoven material to the abrasion to the hole increased almost 2-fold.

Properties of multilayer nonwoven fabric, obtained under optimal conditions, are presented in Table 2.

Table 2

Name of indicators, units	Requirements according to TU 8391-218-00302327-00 (stitched dehumidifying cloth)	Properties of the developed antimicrobial material		Method of tests
		Fiber of hydrophobic layer		
		polyester	polypropylene	
1. width, cm	155±4	155±4	155±4	GOST 3811-72
2. Surface density, g/m^2	170±8	±	±	GOST 3811-72
3. Breaking load, H, not less than along the length along the width	 150 200	 250 230	 240 220	GOST 15902.3-79
4. water absorption, % not less than	300	525	455	GOST 3816-81
5. Air permeabilty, dm^3/m^{2}s, not less than	600	909	650	GOST 12088-77
6. Fungicidal activity, points, no more than	-	3	3	GOST 9.802-84
7. Stability to microbiological degradation, P,%	-	87	87	GOST 9.060-75

Increase in the breaking load of nonwoven fabric is attributable to the formation of a monomolecular layer of organosilicone modifier on the fiber and its chemical interaction with the functional groups of fibers, as well as to the formation of chemical bonds between adjacent fibers. We found that ethoxy oligomers - when fibers are treated with solutions of oligomers (I-II) at room temperature - enter into chemical reactions with functional groups of the polymer fibers (COOH,> C = O, ≡ C-NH-), and the rest is easily hydrolyzed by moisture, which is adsorbed on the fiber surface, turning into silanol groups undergoing subsequent condensation, while the pharmacophore groups $CH_3OC(O)C_6H_4OSi\equiv$ и $C_3H_7OC(O)C_6H_4OSi\equiv$ under these conditions do not undergo chemical transformations and remain covalently bonded to silicon atoms. That is, oligomers are fixed on the fiber surface by covalent bonds

- C-O-Si≡, ≡Si-O-C-O-Si≡, ≡C- NH-Si≡, being simultaneously transformed into

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hydrated silica – $HO(SiO_2)_xOH$. Thus, interdiffusion of macromolecules and their components at the interface of contacting fibers increases, and, consequently, the strength of a nonwoven fabric increases too.

The increase in air permeability of nonwoven fabric with simultaneous reduction of its rigidity is caused by formation of steam and gas-permeable silicone film on the fiber surface.

C O N C L U S I O N S

1. Technology of non-woven two-layer stitched fabric with a hydrophobic layer modified by organosilicone compounds of polypropylene and polyester fibers having antimicrobial properties, has been developed.

2. It has been established that the application of modifiers - oligoethoxy (4 - propylcarboxyphenyloxy)-siloxane (oligomer I) and a mixture of oligomer I with oligoetoxy (4-methylcarboxyphenyloxy) siloxane in a ratio of 4:1 onto the fibers of the hydrophobic layer in an amount from 6.5 to 10 wt%. allows to increase the strength of NVF by 1.1...3.2 times, to increase its water absorption by 1.1...1.46 times and air permeability - by 1.1...1.7 times, to reduce rigidity by 1.7 times, and to increase resistance to abrasion by 2 times.

B I B L I O G R A P H Y

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