Research of the influence of a hydrocarbon coating on the operational stability of membrane fabric

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Abstract. The effect of the hydrocarbon coating on the operational stability of membrane tissues is investigated. Coating on membrane tissues was obtained by plasma-chemical vapor deposition of the products of polymerization and decomposition of acetylene. As a result, the resulting coating allows to: increase resistance to multi-cycle abrasive impact by 9,9-30,1%, while the resistance of the textile base to light, washing, dry and wet friction does not deteriorate; increase tensile strength by 5,7-13,4%; increase elongation to 11,0-18,4%. The stability of fixation of organosilicon impregnation in the structure of the textile base after modification in a nonequilibrium low-temperature plasma increases to 45,5%.

1. The Introduction
The rapid development of the world market of functional materials is an impetus for the improvement and development of domestic production of textile and light industry. The production of textile materials with a membrane coating, which is reflected in the limited range of membrane coatings. The production of materials with a porous membrane coating is associated with the high cost, multi-stage and duration of the technological cycle, in this regard, non-porous membrane coating materials are popular among domestic manufacturers. However, the materials produced have low values of operational stability. Therefore, to increase the competitiveness of domestic membrane tissues, it is not so much the creation of new materials that is relevant, but the modification of existing ones giving them an improved set of properties.

Existing technologies for the modification of textile materials with non-porous membrane coating implies the use of aggressive environments that contribute to the improvement of one property of the material, with the inevitable deterioration of another. Gas discharge modification processes materials are dry, do not require the use of solvents and electrolytes. The use of low-frequency plasma discharge of pressure allows to process polymeric textile materials in inert and reactive gases, without causing destruction and providing a range of new properties.

The aim of this work was to study the effect of hydrocarbon coating on the operational stability of membrane tissues.

2. Materials, methods and equipment
As we used textile materials produced by company «Tchaikovsky Textile», Tchaikovsky: fabric art. 80304 «Climate 150 RS» (100% polyester) with oil- water-repellent impregnation and fabric art. 87015 «Climate 260» (78% polyester, 22% viscose) with water-repellent impregnation.

Modification was carried out in a pilot industrial RF-plasma installation, described in [1]. The plasma modification mode was controlled by varying the parameters: gas flow rate (G) 0,02-0,04 g/s, voltage at the anode of the generator lamp (U₀) 3–7 kV, working pressure in the discharge chamber (P) 26 Pa;
generator frequency \((f)\) 13.56 MHz, processing time \((\tau)\) 1–10 min. A mixture of argon and acetylene in a ratio of 70:30 was used as a plasma-forming gas.

The study of the wear resistance of membrane tissues was carried out according to GOST 18976-73; the resistance of the dyeing of the textile base to light in accordance with GOST 9733.4-83 [2], dry and wet friction in accordance with GOST 9733.27-83 [4]; strength was evaluated according to GOST 30303-95 (ISO 1421-77) [5] on a universal testing machine Shimadzu AGS-5kNX (Japan).

The determination of the fixation stability of organosilicon resins in tissue fibers was determined using the following procedure. Samples of the textile base of the objects of study weighing 0.5 g with a previously removed membrane layer were exposed to deionized water in an amount of 50 ml at a temperature of 90 °C for 60 min. The obtained aqueous solution of the extract was analyzed by inductively coupled plasma atomic emission spectroscopy on an Optima 2000DV instrument manufactured by Perkin Elmer (USA). The results were processed using instrument software.

### 3. Results

Modification of membrane tissues by a nonequilibrium low-temperature plasma in an argon-acetylene medium (70:30) leads to the formation of a hydrocarbon coating from the decomposition and polymerization products of acetylene on the surface of fibers, presumably, alkanes, alkenes, polyacetylene isomers and others [6-9].

The results of the study of operational stability are presented in table 1.

| Material               | Sample       | Breaking load, N  | Elongation at break, mm |
|-----------------------|--------------|-------------------|-------------------------|
|                       |              | warp / weft       | warp / weft             |
| «Climate 150 RS»      | Before modification | 1246/742          | 1122/976                |
|                       | After modification | 1414/814          | 1222/982                |
| «Climate 260»         | Before modification | 54/92             | 76/76                   |
|                       | After modification | 63.3/102.1        | 89.1/90                 |

As can be seen from the results obtained, modified samples of membrane tissues demonstrate an increase in the resistance of the textile base to multi-cycle abrasive effects, in particular, the abrasion resistance of the textile base of the fabric art. 80304 - by 9.9%, fabric art. 87015 - by 30.1%.

The results of experimental studies of the stability of the dyeing of the textile base of the studied materials showed the absence of a significant effect of nonequilibrium low-temperature plasma on the values of these properties.

The values of the breaking load of the studied materials of the initial and modified samples indicate an increase in this parameter for modified samples of the «Climate 150 RS» material - by 13.4% on the basis and by 9.7% on the weft; «Climate 260» material, the breaking load also increases by 8.8% on the basis and by 5.7% on the weft in comparison with the original samples. The elongation at break of textile materials with a non-porous membrane coating after a nonequilibrium low-temperature plasma ranges from 11.0-18.4% for materials «Climate 150 RS» and «Climate 260», respectively. The modification of fabric-based in argon-acetylene medium results in degassing the impregnating composition of the organofluorine preparation with water and oil-water repellent finish, fixing the functional groups of the hydrophobizer on the surface of the fabric fibers, ordering the amorphous phase.

The service life of membrane fabrics with water-repellent and oil-repellent impregnations largely depends on the stable fixation of special impregnations and finishes in the structure of the fabric. The technique for assessing the fixation of organosilicon resins was used for tissue samples art. 80304 and 87015. The results are calculated using the instrument software and are presented in table 2 and figure 1.
Table 2. The elemental composition of aqueous tissue extracts art. 80304 and 87015 before and after modification in a nonequilibrium low-temperature plasma

| Material     | Sample                | The content of elements, mg/l |
|--------------|-----------------------|------------------------------|
|              |                       | Ca  | K   | Mg  | Na  |
| «Climate 150 RS» | Before modification  | 0.302 | 0.148 | 0.038 | 0.447 |
|              | After modification    | 0.136 | 0.106 | 0.025 | 0.309 |
| «Climate 260» | Before modification  | 0.243 | 0.232 | 0.104 | 5.207 |
|              | After modification    | 0.293 | 0.166 | 0.117 | 5.246 |

Figure 1. AES spectra of the elemental composition of aqueous tissue extracts art. 80304 (1) a control sample, (2) a modified sample; fabric art. 87015 (3) control sample, (4) modified sample

From the results of atomic emission spectroscopy, presented in figure 1 and table 3, it can be seen that components containing Na, Mg, Si, K, Ca are removed from the studied materials during aqueous extraction. Presumably, organosilicon impregnations of the studied materials contain organosilicon compounds. Si content in the extract of modified tissue samples art. 80304 and art. 87015 lower by 45.5% and 16.0%, respectively, relative to similar unmodified fabrics, which indirectly indicates an improvement in the fixation of organosilicon impregnation in the structure of the textile base of modified materials.

4. Conclusions

Thus, as a result of the modification of membrane tissues by nonequilibrium low-temperature plasma in an argon-acetylene medium (70:30), a hydrocarbon coating forms on the surface of the material fibers. The formation of a hydrocarbon coating leads to an increase in the operational stability of membrane tissues, namely:

- wear resistance increases by 9.9-30.1%,
- the color stability of the textile base to light, washing, dry and wet friction does not deteriorate;
- tensile strength increases by 5.7-13.4%;
- tensile elongation increases by 11.0-18.4%.

After modification in a non-equilibrium low-temperature plasma, the fixation of organosilicon resins in the structure of the textile basis of fabrics art. 80304 and art. 87015 to 45.5%.
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