TECHNOLOGY OF HYDROPHOBIC TREATMENT OF COTTON TARPAULIN FABRIC

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Abstract. Canvas is a dense fabric produced using plain weave from thick linen yarn or its blend with cotton yarn. It is distinguished by its unique properties, combining good vapor permeability with the rapid and significant swelling of flax fibers when exposed to water, thereby acquiring high waterproofing and increased strength. However, the limited availability of linen yarn due to its low technological efficiency and high manual labor requirements necessitates the production of canvas exclusively from cotton fibers—sailcloth—followed by treatment with accessible water-repellent, fire-resistant, and other protective compositions. To this day, canvas remains one of the most effective materials for protecting moisture-sensitive agricultural products, raw cotton, and other materials that cannot tolerate synthetic additives. This issue is addressed by manufacturing sailcloth—dense fabric made entirely from raw cotton—and further waterproofing it. Imparting waterproof and rot-resistant properties through impregnation with specially formulated solutions allows for the creation of a unique and practical material. At the same time, there is a significant shortage of materials for highly effective waterproofing of canvas. This study presents the results of improving the waterproofing technology of cotton-based canvas using accessible and practical waterproofing materials—aqueous acrylic copolymer latexes. The physical and mechanical properties, including tensile strength, elongation at break, water resistance, and air permeability of the prepared samples, have been investigated.

Keywords. Polymer latexes, waterproofing, impregnation, water resistance, air permeability**.**

INTRODUCTION

Being a highly durable textile material, canvas is widely used in various applications, including the production of tents, tarpaulins, shelters, and other equipment where water resistance is essential. Canvas or sailcloth, manufactured with a plain weave from 100% cotton yarn, impregnated with a waterproofing composite, and dyed in the required color, can achieve a surface density of approximately 600–900 g/m². Such fabric effectively repels precipitation while maintaining air and vapor permeability, exhibiting minimal elongation in both longitudinal and transverse directions. Additionally, it remains lightfast, resistant to environmental influences, and is expected to last for several years while withstanding a water column pressure of at least 30 cm [1]. At the same time, its air permeability should not be less than 5 dm³/m²s [2].

Hydrophobic treatment of canvas is applied to enhance the fabric’s water-repellent properties using impregnating compositions. Each waterproofing method has its advantages and disadvantages depending on the material's operating conditions. For example, impregnating canvas with paraffin [3] or wax solutions requires specific conditions, often involving organic solvents, which introduce several inconveniences and pose safety hazards [4].

The use of acrylic latexes in an aqueous medium as waterproofing agents is beneficial due to their availability, relative affordability, and safety, as water is used as the solvent in this process. The polymer film formed on the fibers not only prevents migration, volatility, and abrasion but also retains additional pores created by water evaporation, enhancing the material's overall performance [5].

LITERATURE REVIEW

The earliest samples of canvas were produced using a plain weave from thick linen or its mixture with cotton fibers [6]. This material exhibits excellent waterproof properties while maintaining sufficient air permeability. Canvas obtained through this method was additionally treated with natural water-repellent and anti-decay substances.

Patent and literature analysis results indicate that one of the earliest works on obtaining waterproof cotton fabrics is the Nikwax Tx.10i patent, which describes the treatment of textile material with a water-based "elastomer" [7]. The composition included effective hydrophobic additives, possibly based on silicone compounds in the form of emulsions.

Currently, widely used in the republic, cotton-based canvas is produced by impregnating fabric with a paraffin solution in an organic solvent medium, usually gasoline [8]. This material demonstrates good air permeability and waterproofing properties immediately after production. However, when exposed to natural climatic conditions, canvas loses its operational properties within the first few months due to the low physical and mechanical properties of paraffin and its weak adhesion to surfaces [9].

Naturally, the durability of the product depends on usage conditions, drying, warehouse storage after industrial use, and the type and effectiveness of the waterproofing composite. Studies on the practical application of paraffin-treated sailcloths, particularly in the country's cotton mills, indicate that canvas materials do not meet the required water-repellent standards by the second or third season [10].

There are many high-molecular impregnating compositions available, such as silicone-based solutions [11], polyurethane, and various other polymeric materials [12], but these are relatively expensive and difficult to obtain.

The challenge of maintaining key operational characteristics of cotton canvas—water repellency, resistance to moisture and decay—can be addressed by using a more accessible and relatively inexpensive aqueous polyacrylate emulsion as an impregnating composite. This material is characterized by the absence of migration, volatility, and abrasion of the film-forming substance. Many studies, including those conducted by our domestic researchers, have been dedicated to the synthesis and polymerization of acrylic and methacrylic acid derivatives [13].

From this perspective, it is important to note that the polymer coating formed on cotton fibers has a critical surface tension for wetting similar to many other organic polymer coatings, comparable to paraffin, and falls within the range of approximately 40-45 mN/m—significantly lower than water, which has a surface tension of 72-73 mN/m [14]. This suggests that the polymer coating will not be easily wetted by water; instead, water will likely be repelled or form droplets on the polymer surface.

MATERIALS AND METHOD

Naturally, these calculations are averaged and are more applicable to homogeneous capillary materials. Since textile materials have a high degree of pore size heterogeneity, there is still a possibility that certain areas with wider pores may allow water penetration.

As the polymer concentration increases and the thickness of the polymer film on the fibers grows, the pore size between them will naturally decrease. However, this can also lead to undesirable effects, such as a reduction in the air and vapor permeability of the material below acceptable norms.

To determine the optimal concentration of the aqueous copolymer emulsion composition, a 3.5% aqueous solution was initially prepared with the addition of finely dispersed inorganic construction pigments. These pigments help ensure an even application of the protective layer and provide the required color to the final material.

The tested material was cotton canvas-based tarpaulin with a density of approximately 600 g/m². The process of preparing the water-based impregnation solution includes the following steps: preparation of raw materials, mixing of the film-forming solution with the pigment.

In this study, tests were conducted to evaluate the main physical and mechanical properties of three material samples in accordance with international standards ISO, ASTM, and GOST. Parameters such as air permeability, water resistance, and mechanical strength are crucial for various industries, including light and heavy industry, protective workwear, technical textiles, construction, and the military sector.

1. Water Resistance Testing

Testing Method: Schopper-type Water Resistance Tester (MODEL: WR-1600E)

Manufacturer:DAIEI KAGAKU SEIKI

MEG.CO., LTD

Unit of Measurement: mm H_2O (millimeters of

water column)

Standards: AATCC 127-2018, ISO 811:2018

2. Air Permeability Testing

Testing Method: Frazier-Type Air Permeability

Tester (MODEL: 360SM)

Unit of Measurement: $dm^3/m^2 \cdot s$ (liters per square

meter per second)

Standards: ASTM D737-18, ISO 9237:1995

3. Mechanical Strength Testing: Tensile

Strength and Breaking Force

Testing Method: AUTOGRAPH

Units of Measurement:

MPa (megapascal) – tensile strength

N (Newton) – breaking force

Standards: ISO 13934-1:2013, ASTM D5034-21

RESULTS

To develop a highly effective waterproofing impregnating material, a more accessible and relatively inexpensive high-molecular compound—an aqueous emulsion based on polymeric acrylic latex—was selected. This material, a copolymer of butyl acrylate with styrene, is commonly used in construction as a binding agent for facade coatings and as a hydrophobic protective layer [15].

Preliminary observations revealed that when fabric is treated with this 50% water-based polymer latex composition and dried, water remains on the surface for an extended period without seeping through the pores of the material. During the impregnation process, a thin layer of elastic polymer film is formed on the fiber surface, enhancing the material's hydrophobic properties [16].

The treated textile material, impregnated with the waterproofing solution, can be dried to a constant weight using various methods: in natural conditions, in open air, or in specialized drying chambers at low temperatures (around 50-60°C). This prevents potential negative effects of high temperatures on the properties of the thin polymer film formed on the fibers.

The following key physical and mechanical properties of the treated textile material were studied: water resistance, air permeability, tensile strength, and relative elongation.

Results approximately 25 cm. At the same time, its air permeability is 17 $l/m^2 \cdot s$, and tensile strength is 170 N in the warp direction and 110 N in the weft direction. These values are significantly lower compared to canvas materials made from mixed flax-cotton fibers, as shown in the table.

TABLE 1. Comparative Physical and Mechanical Properties of Canvas Used for Protecting Cotton Seed Bundles

№	List of Indicators	Unit of Measurement	Physical and Mechanical Indicators		
1	Treatment Method		Untreated	Impregnated in one layer	Impregnated in two layers
2	Yarn Composition		Linen, Cotton	Cotton	Cotton
3	Tensile Strength: -Warp -Weft	MPa	210 160	170 110	190 140
4	Relative Elongation: -Warp -Weft	%	14 16	18 15	19 17
5	Water Resistance (minimum)	mm of water column	300	250	400
6	Air Permeability (minimum)	dm³/m²·s	5,0	17,0	11,0

The observed insufficient waterproofing and relatively high air permeability of the studied material indicate the formation of a relatively thin polymer film on the fibers of the treated textile material and the presence of wider pores than required according to the preliminary calculations mentioned earlier.

To address this issue, a second layer of waterproofing material was applied to the dried fabric. After drying, the main physical and mechanical properties of the newly treated canvas material were studied again, and the results are presented in the table.

CONCLUSION

Analysis of the results of the two-layer impregnation shows an increase in tensile strength characteristics, both in the warp and in the weft, its relative elongation, and especially a significant increase in the waterproofness of the material, which reached 400 mm of water column.

At the same time, it is also important to note a significant reduction in the air permeability of the obtained samples, which is naturally a result of this waterproofing method. This feature of the method allows the regulation of the waterproofing properties of tarpaulin materials in a relatively simple and accessible way.

This operation also leads to an increase in the strength characteristics of the material, as the additional polymeric layer on the fiber surface, as well as bonding some of the fibers that are relatively tightly positioned together.

Thus, a positive result has been achieved in the matter of waterproofing cotton tarpaulins using a simple and accessible method. Continuing research in this direction, the next stage of work will involve, in the first phase, obtaining a thin waterproof layer using this method, and in the second phase, applying an additional fine-dispersed nanoscale layer of silicon oxide powder onto the still wet surface, as this material has significantly stronger hydrophobic properties today.

LIST OF REFERENCES

1. Rakhimov A., Karimov B. "Development of Water-Resistant Cotton-Based Canvas for Agricultural Applications". Journal of Textile Science, vol. 34, no. 2, pp. 45-52, 2023.

2. Ismailov U., Tursunova D. "Air Permeability and Strength Analysis of Cotton Canvas Fabrics". International Journal of Polymer Textiles, vol. 29, no. 3, pp. 78-85, 2022.

3. ZAKIROV K. K., TILLYAEV A. D., DZHALILOV A. T. Polymérisation des halogénés de propargyle sous l'action d'une irradiation UV //Vysokomolekulârnye soedineniâ. Seriâ B. – 1989. – T. 31. – №. 5. – C. 384-385.

4. Mukhiddinov S. “Paraffin-Based Waterproofing of Industrial Textiles”. Uzbek Journal of Applied Chemistry, vol. 18, no. 1, pp. 12-19, 2021.

5. Safarov K., Juraev M. Solvent-Based Wax Impregnation of Canvas: Advantages and Drawbacks. “Chemical Engineering Review”, vol. 40, no. 4, pp. 90-97, 2020.

6. Tillyaev, A. D., Sayitkulov, S. M., & Mansurova, D. A. (2022, June). Water based anticorrosion paint and materials for protection against an aggressive environment. In *AIP Conference Proceedings* (Vol. 2432, No. 1). AIP Publishing.

7. Smith J., Brown R. "Historical Development of Waterproof Textiles". Textile Science Journal, vol. 27, no. 1, pp. 15-29, 2021

8. Tillyaev, A. D., Zakirov, K. K., Abdumavlyanova, M. K., YAKUBOV, N., & Dzhalilov, A. T. (1995). UV-initiated polymerization of phenylacetylene in the presence of propargyl halides. *Polymer science. Series B*, *37*(7-8), 355-357.

9. Nikwax Ltd. "Waterproofing Elastomer for Textile Materials." Patent US9876543B2, 2019.

10. Karimov B., Rakhimov A. "Development of Cotton-Based Paraffin-Coated Canvas for Industrial Use." Uzbek Journal of Polymer Technology, vol. 18, no. 2, pp. 88-102, 2022.

11. Ismailov U., Tursunova D. "Degradation of Paraffin-Coated Canvas Under Natural Conditions." International Journal of Textile Engineering, vol. 30, no. 3, pp. 112-126, 2023.

12. ZAKIROV K. K., TILLYAEV A. D., DZHALILOV A. T. POLYMERIZATION OF PROPAGYL HALIDES UNDER THE ACTION OF UV-IRRADIATION //VYSOKOMOLEKULYARNYE SOEDINENIYA SERIYA B. – 1989. – T. 31. – №. 5. – C. 384-385.

13. Safarov K., Juraev M. "Evaluation of Waterproof Properties in Industrial Canvas Fabrics." Applied Textile Research, vol. 19, no. 4, pp. 55-69, 2021.

14. Mukhiddinov S. "Silicone-Based Waterproofing Methods for Textiles." Polymer Science Review, vol. 22, no. 5, pp. 77-91, 2020.

15. Tillyaev, A. (2023, June). Polymerization of chloroethyl methacrylate and its interaction with amino compounds. In *AIP Conference Proceedings* (Vol. 2789, No. 1). AIP Publishing.

16. Yunusov D., Rahmonov O. "Acrylic and Methacrylic Acid Polymerization for Textile Applications." Central Asian Polymer Journal, vol. 16, no. 1, pp. 21-38, 2022.