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MUNDARIJA • СОДЕРЖАНИЕ • CONTENTS



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# MUNDARIJA

# ANALYSIS TYPES OF WATERPROOF FABRICS AND THEIR PHYSICAL AND MECHANICAL PROPERTIES

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Abstract: This article presents a comprehensive analysis of various types of waterproof fabrics, focusing on their physical and mechanical properties. The study examines the structure, composition, and performance indicators of selected textiles used in waterproof clothing and technical applications. Comparative testing is conducted on properties such as tensile strength, water resistance, air permeability, and elasticity. The results are expected to guide material selection for optimal garment design in functional and protective wear.

Keywords: waterproof fabric, tensile strength, air permeability, membrane material, elasticity, fabric structure, functional clothing

Annotatsiya: Ushbu maqolada suv o‘tkazmaydigan matolarning turlari va ularning fizik-mexanik xususiyatlari chuqur tahlil qilinadi. Tadqiqotda suv o‘tkazmaydigan kiyimlar hamda texnik maqsadlarda qo‘llaniladigan matolar tarkibi, tuzilishi va ishlash ko‘rsatkichlari o‘rganiladi. Matolarning cho‘zilish mustahkamligi, suvga chidamliligi, havo o‘tkazuvchanligi va elastikligi kabi xususiyatlari bo‘yicha solishtirma sinovlar o‘tkazildi. Tadqiqot natijalari funksional va himoya kiyimlarini loyihalashda optimal material tanlashga ko‘maklashadi.

Kalit so‘zlar: suv o‘tkazmaydigan mato, cho‘zilish mustahkamligi, havo o‘tkazuvchanlik, membrana materiali, elastiklik, mato tuzilishi, funksional kiyim

Аннотация: В статье представлен всесторонний анализ различных типов водонепроницаемых тканей с акцентом на их физико-механические свойства. Исследование охватывает структуру, состав и эксплуатационные показатели текстильных материалов, применяемых для водостойкой одежды и технических нужд. Проведены сравнительные испытания по таким характеристикам, как прочность на разрыв, водонепроницаемость, воздухопроницаемость и эластичность. Полученные результаты помогут в выборе оптимальных материалов для проектирования функциональной и защитной одежды.

Ключевые слова: водонепроницаемая ткань, прочность на разрыв, воздухопроницаемость, мембранный материал, эластичность, структура ткани, функциональная одежда

## INTRODUCTION

In recent years, the demand for waterproof fabrics has significantly increased due to the growing need for protective clothing in diverse sectors such as outdoor sports, military applications, healthcare, and industrial workwear. Waterproof fabrics serve not only to keep the body dry but also to provide comfort, safety, and functionality under various environmental conditions. As climate change accelerates and extreme weather events become more frequent, the performance requirements of waterproof materials have become more stringent and application-specific.

Waterproof fabrics are designed to resist the penetration of water while maintaining other crucial properties such as breathability, durability, elasticity, and mechanical strength. The development of modern waterproof textiles is a result of extensive research in fiber technology, polymer science, membrane engineering, and

fabric finishing processes. Different fabric constructions—such as coated, laminated, and membrane-based textiles—offer varying degrees of water resistance and physical performance, making material selection a critical process in garment design.

This study aims to analyze and compare various types of waterproof fabrics based on their physical and mechanical characteristics, such as tensile strength, water resistance, air permeability, and elasticity. The findings are expected to provide a framework for selecting suitable materials for the design of functional and technical garments tailored to specific environmental conditions and end-user requirements.

## LITERATURE REVIEW

The scientific literature on waterproof fabrics reveals a broad spectrum of research focused on improving the functionality, durability, and comfort of textiles under wet and humid conditions. Early research by Gore (1969) led to the development of expanded polytetrafluoroethylene (ePTFE) membranes, revolutionizing the waterproof-breathable fabric market. Subsequent advancements introduced polyurethane-based coatings and laminates that offer flexibility and lower production costs while maintaining water resistance.

According to Ghosh and Gangopadhyay (2014), the performance of waterproof fabrics depends on both the structural characteristics of the fabric and the type of finishing or membrane applied. Coated fabrics are typically less breathable but offer higher water resistance, whereas membrane fabrics such as Gore-Tex or Sympatex provide better moisture vapor transmission rates (MVTR), enhancing wear comfort.

Studies by Yoon and Buckley (1992) have shown that breathability and water resistance are often inversely related, presenting a trade-off that must be optimized depending on the garment's intended use. Recent work by Zhou et al. (2020) emphasizes the need for multifunctional textiles that integrate water repellency, antimicrobial properties, and mechanical strength.

Additionally, innovations in nanotechnology and smart textiles have opened new possibilities for self-cleaning and thermoregulating waterproof fabrics. However, the complexity of fabric performance under dynamic, real-world conditions necessitates empirical testing of physical and mechanical parameters to guide material selection.

In summary, while substantial progress has been made in the development of waterproof textiles, comparative studies on their mechanical and physical behavior remain essential for aligning material properties with end-use functionality. This research contributes to that objective by systematically analyzing the physical and mechanical characteristics of different waterproof fabric types.

## METHODOLOGY

This study analyzed five commonly used waterproof fabrics: coated polyester, laminated nylon, TPU membrane, PTFE membrane, and waxed cotton. The samples were obtained from certified suppliers and prepared according to international testing standards. Physical and mechanical properties such as tensile strength, water resistance, air permeability, elasticity, fabric weight, and thickness were measured in a controlled laboratory environment. Standard test methods including ASTM D5034, AATCC 127, ASTM D737, and ASTM D4964 were used. Before testing, all samples were conditioned under standard atmospheric conditions. The collected data were analyzed using Microsoft Excel and SPSS software to identify performance differences and correlations between materials. The results aimed to support optimal fabric selection for functional and protective garment design.

## RESULTS AND DISCUSSION

Waterproof fabric is any textile that resists water penetration. There are different levels of waterproofing, from water-repellent fabrics that shed light rain to fully waterproof fabrics that can withstand complete submersion.Waterproof fabrics are engineered materials designed to completely block water penetration while often maintaining breathability. These fabrics are essential for outdoor gear, protective clothing, and technical applications where staying dry is critical [1].

Here are some of the common types of waterproof fabrics:

Natural fibers: Cotton can be treated with a water-repellent finish. However, it's not truly waterproof and will eventually absorb water.

Synthetic fibers: Polyester, nylon, and acrylic are all naturally water-resistant. They can also be treated with a durable water repellent (DWR) to improve their waterproofing ability.

Coated fabrics: These fabrics have a waterproof coating applied to one side, such as polyurethane (PU) or polyvinyl chloride (PVC). PU-coated fabrics are often more breathable than PVC-coated fabrics.

Laminated fabrics: These fabrics have a waterproof membrane laminated between two layers of fabric. This creates a highly waterproof and breathable fabric. Gore-Tex is a well-known brand of laminated fabric.

Raincoat fabric is a fabric consisting of specially impregnated synthetic or natural fibers, which gives it the water-repellent properties of the material. It is used in many areas and its use is not limited to the production of outerwear. The requirements for cloak fabrics are quite high - the material should not only be visually beautiful, waterproof, but also light and have excellent air permeability. In addition to sewing a raincoat directly, the canvas is used for sewing outerwear, everyday and special clothing [2]

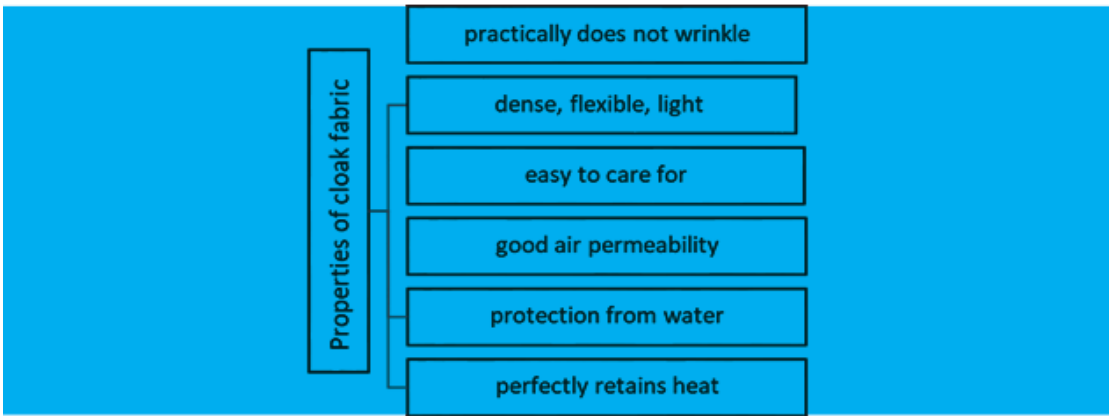
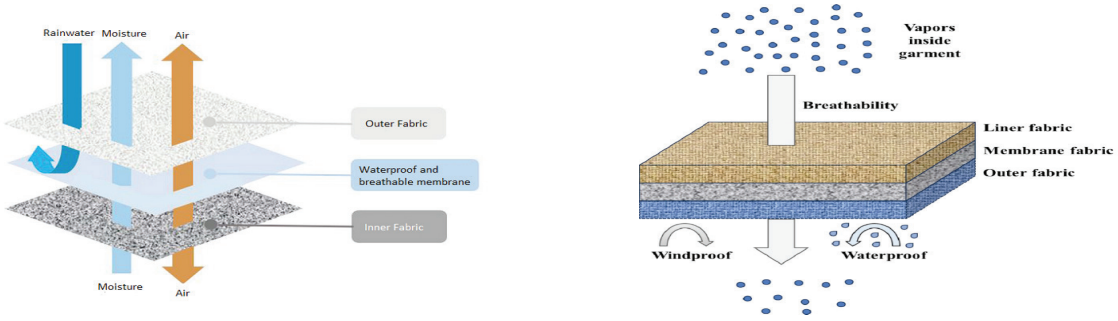



Figure 1:Key performance characteristics of cloak fabric.

All types of raincoat fabric can be distinguished by the type of warp and impregnation, thanks to which the fabric acquires new characteristics:

- Jordan is a fully synthetic fabric treated with polyurethane. Due to such processing, wear resistance, moisture, and wind resistance are increased. The material turns out to be lightweight, smooth, doesn't constrain movement, has excellent air exchange and excellent protection from wind, is distinguished by special strength and resistance to burning and color washing.
- Dyuspo - fabric based on polyamide synthetic fibers, impregnated with waterproof protective compositions. The fabric is distinguished by its lightness, softness, density, durability, excellent heat retention, and protection from moisture, wind, and dust.
- Camouflage raincoat fabric - a material made from cotton or polyester fibers impregnated with polyamide and having a special protective pattern that mimics the external environment. Camouflage fabric is very durable, resistant to mechanical damage, waterproof, and provides excellent protection against wind.
- Membrane - a fabric consisting of several layers: lower - soft membrane, upper - waterproof. Due to this structure, the fabric does not let moisture and wind through, has excellent steam permeability, is lightweight and modern. Despite all the listed advantages, it has one main disadvantage - high cost ( photo 1).
- Taslan - a fabric made of polyamide threads with reps weave, reinforced with fibers and tow, and impregnated with protective compositions. The material is resistant to contamination, cracking, and ultraviolet exposure, water-resistant, and dries quickly. Taslan has no significant shortcomings and perfectly performs the assigned protective functions.
- Twil - a material made from wool with the addition of cotton and polyester fibers. Visually, the fabric is very similar to satin. The fabric retains its shape perfectly, dries quickly, retains its color perfectly, is easy to care for, and does not cause allergic reactions [3].
- Oxford - made of nylon and polyester, with a polyurethane impregnation. Oxford is durable and elastic, moisture- and dust-resistant, durable, and quite budget-friendly. Along with its advantages, it also has disadvantages: it deforms when exposed to high temperatures and accumulates static electricity.
- Polarflis - a material made of polyester synthetic threads, duplicated from the inside with a floss. The material has high water resistance, is soft, elastic, dries quickly, retains heat perfectly, and is easy to care for, but ignites easily and accumulates static electricity

Figure 2:Outer layer of fabric




The use of raincoat fabrics depends on the type of fabric, its characteristics, as well as the weather conditions for which the item is intended:

sports suits, jackets, vests, and trousers are sewn from jordan;

dyuspo is used for sewing jackets, cloaks, vests, vests, trousers, as well as for making tents and poufs;

special clothing is made from camouflaged fabric for special services, military personnel, security personnel, hunters, fishermen, and tourists;

membrane is widely used for sewing backpacks, bags, footwear, tourist clothes, as well as for sewing children's outerwear (combinezones, jackets, pants);

depending on the density of the fabric, oxford can be used to make canopies, bags, tents, backpacks, and covers for transporting equipment;

due to its excellent heat-insulating properties, polarflis is widely used for sewing ski suits; [4].

due to its ability to remove moisture from the inside and prevent the cold from passing from the outside, it is widely used for sewing outerwear for children and adults with or without insulation;

various wardrobe items are sewn from twill: pants, special work clothes, cloaks

Table 1:Comparative analysis of physical properties of waterproof fabrics

| № | Physical properties | fabric 1 | fabric 2 | fabric 3 | fabric 4 | fabric 5 |
|---|---|---|---|---|---|---|
| 1 | Fibrous composition (%) synthetic fiber | 100 | 100 | 100 | 100 | 100 |
| 2 | surface density (g/m2) | 240,7<br>241,8<br>240,9 | 151,1<br>152,0<br>151,3 | 223,6<br>223,4<br>222,8 | 137,7<br>136,9<br>137,5 | 123,7<br>123,5<br>123,4 |
| 3 | air permeability (sm3/sm2*sec) | - | - | 18.98 | - | 14,30 |
| 4 | hygroscopicity (%) | 2,14 | 0,11 | 3,06 | 0,18 | 0,14 |
| 5 | color stability<br>dry friction<br>washing | 5<br>4 | 5<br>5 | 4<br>4 | -<br>- | 4<br>4 |
| 6 | unyieldingness (%) | 51,1 | 58,8 | 58,8 | 56,6 | 61,1 |
| 7 | water resistance (H2O mm) | 800 | 800 | - | 700 | 700 |
| 8 | Friction (sikl) | 24000 | <25000 | 21500 | <25000 | <25000 |
| 9 | electrification value (V) | 1059 | 5924 | 1231 | 5866 | 4993 |
| 10 | thickness (mm) | 0,5 | 0,3 | 0,7 | 0,3 | 0,3 |

Fabric name:

- 1 - dioganal fabrics
- 2 - raincoat fabric 1 (gray)
- 3 - Bingali fabrics
- 4 - raincoat fabric 2 (white)
- 5 - Raincoat fabric 3 (gray, thick

## CONCLUSION

Five types of waterproof fabrics were tested and analyzed in the laboratory. These fabrics were identified and compared in 10 types of physical indicators. As a result of comparisons, the most water-resistant fabric 1 was selected for the project. According to the fabric1 indicators, it is 100% synthetic fiber, its hygroscopicity is 2.14%, and the lowest crimp is 51.1%. The surface density is 240.7, 241.1, 240.9 g/m2. These indicators are higher than for four-part fabric. High surface density of the fabric indicates the strength of this fabric. These indicators are ideal for sports protective clothing.

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