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EFFECT OF ENVIRONMENTALLY FRIENDLY WATER REPELLENT PROCESS ON COMFORT PROPERTIES OF COTTON-POLYESTER BLENDED FABRICS

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Abstract

Although fluorocarbon-containing finishing chemicals used for water repellency finishing processes are effective in providing the desired properties, they negatively affect the environment. The chemicals it contains come into contact with the environment after various processes (washing, etc.) and over time, although the textile products used are natural (natural or sustainable fibers), their negative effects have become undeniable due to the harmful chemicals used in the finishing processes. The chemicals in its content meet the environment after various processes (washing, etc.) and over time, although the textile products used are natural (natural or sustainable fibers), their negative effects have become undeniable due to the harmful chemicals used in the finishing processes. In this study, fluorocarbon-free, environmentally friendly green water repellent finishing process that can last longer than other standard coatings was applied to the knitted cotton-polyester blend fabric produced with Ne 30/1 three yarn (30/70/10). After the water repellency finishing processes of the produced knitted fabric, water repellency, comfort, air permeability and drape tests were applied. The results of fluorocarbon containing and environmentally friendly water repellency processes were compared in certain parameters. The final result of this study green environmentally friendly water repellent finishing processes did not cause any negative effects in comfort tests, air permeability values and drape test values compared to non-environmentally friendly (fluorocarbon etc. content) finishing processes and even showed positive effects in these valuesThe results of the study were obtained upon completion support the environmentally friendly approach and will also shed light on green water repellent finishing processes being the reason for preference in the future.

Keywords: Water repellency, finishing, dwr, green conversion

1. Introduction

Cotton is known as the plant whose fibers are most utilized Cotton fibers are highly preferred due to their natural and physical properties [1]. Cotton is a fiber that is mostly composed of cellulose and the rest is water and organic matter. Thanks to its content, it is a biodegradable fiber.

Applications made by treating the surface of the textile product or the body it covers with various finishing materials to protect it from water are called water repellent finishing processes. These processes provide water-repellent properties to the fabric while completely preserving the appearance and permeability of the fabric. The water-repellent finishing process allows the passage of water vapor from the fabric surface by creating a film layer with a hydrophobic and porous structure without dissolving on the fabric surface [2]. Fluorocarbons are generally preferred in textile products because they reduce surface tension [3].

Fluorocarbons are compounds containing C-F bonds [4]. Fluorocarbons exhibit hydrophobic properties and repel liquids on the fabric surface [5]. Fluorocarbons are preferred in various fields such as non-stick cookware, textile coatings, fire foams, cosmetics, refrigerants and medical applications [6]. However, they are also called 'forever chemicals' because they remain intact in nature for thousands of years [7]. This current structure of carbon chains pollutes the environment in the long term.

Fluorocarbon polymers are among the standard product groups used in water, oil and dirt repellent finishing processes as they meet the necessary needs of the textile industry. They are widely used in many areas from textile to automotive [8]. However, like many processes applied to cotton in textiles, the chemicals containing fluorocarbons used to impart water repellency in finishing processes cast a shadow over the environmental friendliness of cotton. For example, although fluorocarbon-containing finishing chemicals used to provide water repellency are very effective in providing the desired properties, they affect the environment quite negatively. It has been noted that trifluoroacetic acid, a by-product of fluoropolymers, remains naturally present even at a depth of 4000 m in seawater [9]. In addition, considering the effects such as the ozone layer depletion it is thought to cause, it has become necessary to find an alternative to water repellent chemicals containing fluorocarbon polymers. Many water repellent chemicals contain fluorinated compounds to repel water. Standard fluorocarbon molecules have a 6- to 8-carbon chain structure that does not break down easily in the environment. This current structure of carbon chains pollutes the environment in the long term. Green water repellent finish is seen as a good alternative to environmentally friendly water repellent finishes because it has a shorter chain structure and does not contain fluorocarbons.

Various research has been conducted on alternatives to fluorocarbon compounds in water repellency processes that do not harm the environment or human health. In the study conducted with biobased water-repellent polymers, Sharif and colleagues noted that the textile surface on which biobased water-repellent polymer was applied still maintained its water repellency after more than 20 washes [10]. In their study, Guo and his colleagues stated that water repellency was achieved by covering the surface with silicone [11]. In their study, Yue and her colleagues stated that both hydrophobic and mechanical / washing resistance on the cotton surface increased in amino-alkyl polysilsiloxane + nanosilica applications [12]. It is known that many water repellent finishing processes (DWR) negatively affect the comfort properties and air permeability of fabrics after application [13].

As an example of the alternatives mentioned in this study, an environmentally friendly water repellent chemical that does not contain fluorocarbon and can last longer than other standard coatings was used for the knitted cotton garment produced with Ne 30/1 three yarns (30/70/10). After the water repellency process of the produced knitted fabric, water repellency, comfort, air permeability and drape tests were applied. The results of fluorocarbon-containing and environmentally friendly water repellent treatments were compared.

2. Materials and Methods

Table 1. The obtained sample fabric and the applied finishing process

Sample Fabric Code	Fabric Type	Applied Finishing Process	Pus/Fein	Product Gr/m^2
AX	30/70/10 RP/POL/RK	Green Eco-Friendly Water Repellent Chemical	32/20	290

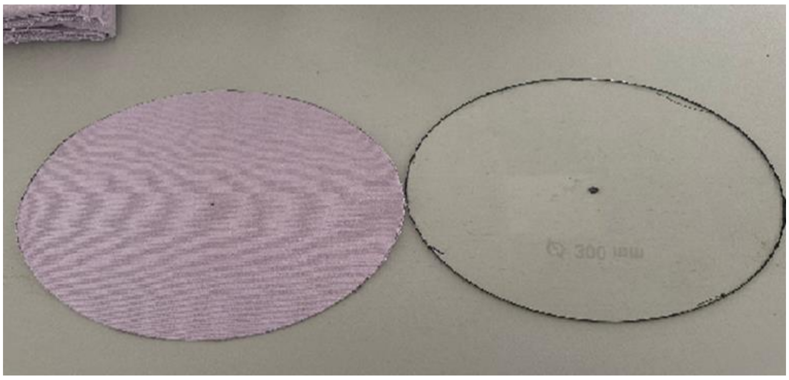

Figure 1. Fabric samples prepared for analysis.

The purpose of the water repellency test is to determine whether the droplets falling on the fabric surface remain on the surface. In this study, 30/70/10 RP/POL/RK three-thread fabric was produced using Ne 30/1 cotton yarn, 70 denier polyester filament and Ne 10/1 cotton yarn to compare the non-environmentally friendly (containing fluorocarbon) and environmentally friendly green water repellent finish (Table 1). Environmentally friendly green water repellent finishing processes have been applied to the fabric produced. All of these production steps were carried out within the body of İskur Tekstil Enerji Tic. ve San. A.Ş.

Water repellency analyses were carried out within the framework of TS EN ISO 4920 standards. First of all, the fabrics to be analyzed were prepared in 20 cm dimensions (Figure 1). The fabric sample was kept in the test room standards (65% relative humidity, 21℃) for 24 hours. The fabric is placed tautly on the stabilizer frame. During the test period, 250 ml of pure water was sprayed onto the textile surface for 20-30 seconds. Then the result was evaluated.

Water vapor and thermal resistance analyses were carried out considering ASTM E96 standards. For the analysis, fabrics were prepared in 20 cm dimensions. The fabric sample was kept in the test room standards (65% relative humidity, 21℃) for 24 hours. Distilled water was added into the test container and the mouths were closed with sample fabric samples. In order for this test to give accurate results, the test container must be completely covered with the fabric surface. A high precision scale was used in the test container to obtain more accurate results. In this way, it was kept at 23 °C and 50% relative humidity for 24 hours and weighed again after the process was completed. The same process was applied to all prepared samples and appropriate evaluations were made at the end of the process (Figure 2).

Figure 2. Water vapor permeability tester.

Air permeability test was measured in accordance with TS 391 EN ISO 9237 standards. Test fabrics are connected by writing the air rate passing through a 20 cm^2 test area at a pressure of 100 Pascal (Pa) in litres/square metre/second (L/M^2.s). Before the experiment, the samples were prepared in 20 cm x 20 cm dimensions and kept in an environment with 65% relative humidity and 21℃ temperature for 24 hours. Sample fabrics were placed in the testing device and a pressure of 100 Pa was applied, and the passing air was measured with sensors (Figure 3).

Figure 3. Air permeability test device (Şengül.2024).

Fabric drape test was conducted in accordance with TS 9693 standards (Figure 4). In the test, fabric samples were cut to 20 cm x 20 cm dimensions and it was observed how they took shape with their own weight. For drapeability measurement, the sample was suspended freely in the right-left and up-down axes, and the natural folding, wrinkling and bending properties of the sample were evaluated. This evaluation was made with observational and measurement criteria to determine the degree of drape in accordance with the standard. The results were scored according to the TS 9693 standard and the average values were reported.

Figure 4. Air permeability test device [14].

3. Results and Discussions

In the details of the work done, the drape test was carried out in accordance with the TS 9693 standard in order to determine the comfort properties, water repellency (Figure 5), air permeability and sagging shape of the fabric under its own weight of the AX-coded fabric produced by applying an environmentally friendly finishing process.

Figure 5. Eco-friendly water repellent treated fabric (water repellent effect).

Table 2. Water vapor permeability and thermal resistance coefficient measurement results of AX code fabric

Sample	AX - 30/70/10 10 RP/POL/RK Three Thread Fabric		
	Water Vapor Permeability		
	Relative Water Vapor Permeability (%)	Water vapor permeability coefficient (WVPR)	Thermal Resistance(W/m²)
1	48.05	5.93	0.021861
2	44.49	6.68	0.018086
3	47.90	5.87	0.019358
Mean	46.79	5.99	0.020692

The cotton in the fabric structure increases breathability while reducing water repellency. In addition, the polyester contained in the fabric is expected to reduce water vapor permeability. In line with the data obtained, it is desired that water repellency and water vapor permeability are reduced [15].

In the measurements made on three samples of AX- 30/70/10 RP/POL/RK three-yarn fabric, water vapor permeability values were determined as 48.05%, 44.49% and 47.90%, respectively. The average water vapor permeability coefficient (WVTR) was calculated as 5.99. Thermal resistance value of similar samples were measured as 0.021861, 0.018086 and 0.019358 W/m², respectively, and the average thermal resistance was 0.020692 W/m² (Table 2). The results obtained are very important in terms of learning the air permeability of the fabric.

Figure 6. Water repellency tester.

The water vapor permeability and thermal resistance measurement results of the AX coded fabric showed that this fabric has balanced properties in terms of moisture management and thermal comfort. With an average water vapor permeability of 46.79%, the fabric has the ability to expel the user's sweat, and the WVPR value of 5.99 indicates that this permeability is stable. Additionally, the average heat resistance of 0.020692 W/m² indicates that the heat retention capacity of the fabric is limited but somewhat protective.

These findings suggest that AX fabric can be preferred in summer months or active use scenarios high water vapor permeability, should be supported with layered clothing in cool environments due to its low thermal resistance. These values reveal that the fabric offers a functional structure in terms of comfort performance.

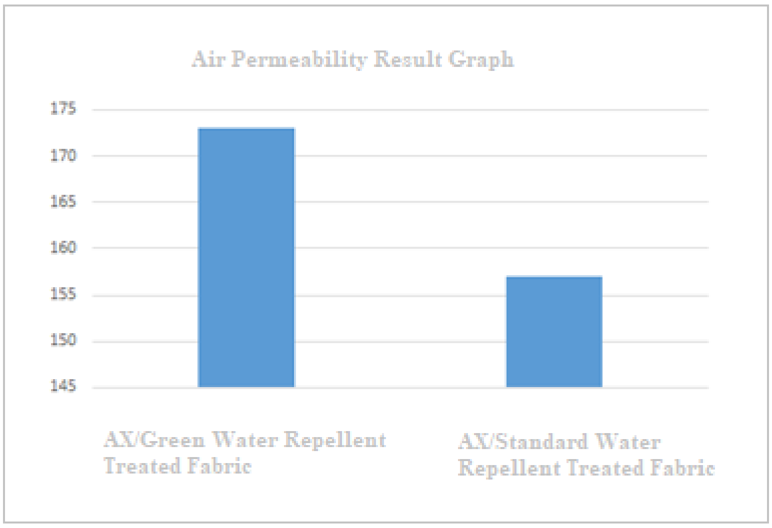

Figure 7. Air permeability test result graph of AX code fabric.

In the light of air permeability analysis data on the AX coded sample, different finishing processes significantly affected the air permeability performance of the fabric (Figure 7). The air permeability of the green water repellent finished sample was measured as 172 units on average, this value was approximately 152 units in the standard water-repellent finished fabric. This result shows that the green water repellency treatment has an effect of increasing the air permeability of the fabric.

Different water repellency finishing processes applied to the AX coded fabric created significant differences in air permeability. It has been observed that the green water repellent finishing process provides better air permeability compared to the standard process.

This means that green water repellent chemicals are less likely to clog the fabric surface or leave a more flexible oil. It is thought that choosing green water repellency can be beneficial in terms of improving product properties, especially in areas where breathability is important (e.g. outerwear or sports textiles). In addition, this situation reveals that environmentally friendly finishing can create positive effects not only ecologically but also functionally.

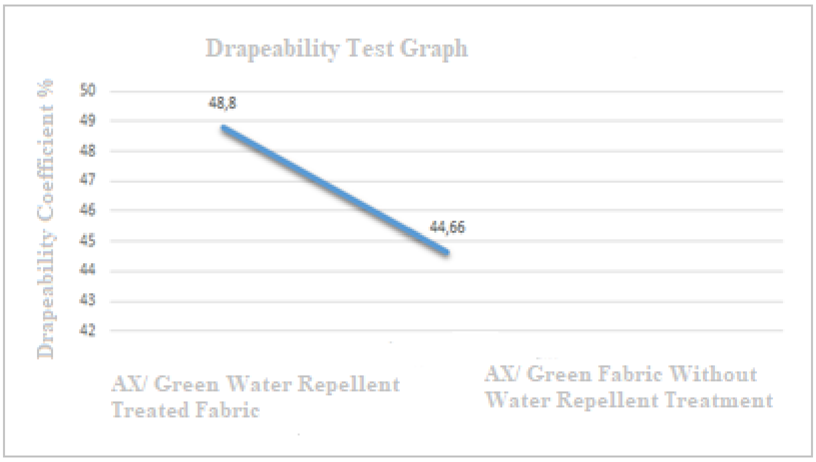

Figure 8. Drape test result graph of AX coded fabric.

At the end of the drape test, the drape coefficients of the Ax coded fabric were examined after different finishing processes. While the drape ratio of the AX sample without green water repellency finish was measured as 48.8, this value dropped to 44.66 in the fabric subjected to the same treatment (Figure 8). This result shows that the finishing process significantly affects the drapeability of the fabric.

According to the drape test results performed on the AX coded fabric, a significant decrease in the drape coefficient of the fabric was observed when the green water repellent finishing process was applied. This suggests that the water-repellent finishing process changes the surface properties of the fabric, reducing its mobility and softness. A decrease of approximately 8.5% in the number of drape folds indicates that the finishing process limits the flexibility and natural flow of the fabric. This result reveals that the drape properties of the fabrics to be finished should be carefully evaluated according to their usage area.

4. Conclusions

In this study, the drape, air permeability, water vapor permeability and thermal resistance properties of the AX coded fabric were investigated; the effects of different finishing processes on the physical and comfort performances of the fabric were evaluated. The findings revealed that the fabric has versatile usage potential.

Drape test results showed that the green water repellent finish reduced the folding modulus of the sample and gave it a harder structure. This situation has been evaluated as an important parameter in terms of aesthetic appearance and mobility. In the air permeability test, it was determined that the fabric with green water-repellent finish had better air conductivity than the fabric with standard water-repellent finish. This result shows that environmentally friendly coating provides advantages not only in terms of long-term use but also in terms of consumer satisfaction.

In water vapor permeability measurements, the average relative water vapor permeability of the fabric was calculated as 46.79% and the water vapor coefficient was calculated as 5.99. These values showed that the fabric could effectively transfer sweat and was successful in terms of moisture management.

Thermal resistance measurements showed that the fabric had a low heat retention capacity (avg. 0.020692 W/m^2). This suggests that the fabric is suitable for providing thermal comfort in hot weather or active use conditions, but should be used with supportive layers in cold weather conditions.

As a result, the AX coded fabric has very advantageous features in terms of breathability, moisture management and environmentally friendly finishing processes. However, drapability and thermal comfort performance should be carefully evaluated according to the desired place of use. The data obtained increase the preferability of the fabric in functional clothing products and active usage scenarios.

Within the scope of this study, the application of green water repellent finishing process reveals its superiority compared to non-environmentally friendly finishing processes. In addition to bringing a different perspective to the non-environmentally friendly (fluorocarbon-containing) water repellent finishing processes applied in the textile industry, it is also envisaged to bring a sustainable approach thanks to its environmental sensitivity (since it does not contain harmful chemicals such as fluorocarbons).

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