



INVESTIGATION OF THE STRUCTURAL AND PERFORMANCE PROPERTIES OF ELASTANE-CONTAINING FABRICS

Scientific paper
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ABSTRACT: Elastane-containing fabrics are widely used in textile applications due to the comfort and flexibility they provide. Despite these advantages, various problems such as pilling, dimensional changes, surface deterioration, and elastane protrusion may occur during use and care processes, affecting both the appearance and performance of the fabric. Therefore, evaluating the structural and performance properties of elastane-containing fabrics is important for assessing their serviceability and quality. Accordingly, this study aimed to investigate the structural and performance characteristics of a plain-woven fabric composed of 90% polyester and 10% elastane. For this purpose, a series of physical, mechanical, surface, and color-related tests were conducted, including fabric weight, thickness, warp and weft density, fabric and yarn tensile strength, air permeability, pilling resistance, color measurement, laundering fastness, and rubbing fastness. In addition, test results provided by the manufacturer were incorporated into the evaluation and compared with the laboratory findings. The results indicated that the investigated fabric exhibited generally favorable performance in terms of structural properties, strength behavior, surface appearance, and color durability. No significant surface deterioration or elastane protrusion was observed during the surface evaluations, while the fastness tests demonstrated satisfactory resistance to laundering and rubbing conditions. Overall, the findings suggest that the 90% polyester / 10% elastane plain-woven fabric possesses suitable performance characteristics for its intended end-use applications.

Keywords: Elastane, Elastane Fabric, Woven Fabric, Fabric Performance, Elastane-containing fabric.

ISPITIVANJE STRUKTURNIH I PERFORMANSNIH
SVOJSTAVA TKANINA KOJE SADRŽE ELASTAN



APSTRAKT: *Tkanine koje sadrže elastan široko se koriste u tekstilnim primenama zbog udobnosti i fleksibilnosti koje pružaju. Uprkos ovim prednostima, tokom upotrebe i procesa održavanja mogu se javiti različiti problemi, kao što su piling, dimenzionalne promene, površinska degradacija i izbijanje elastanskih vlakana, koji utiču kako na izgled tako i na performanse tkanine. Stoga je ispitivanje strukturnih i performansnih svojstava tkanina sa elastanom od velikog značaja za procenu njihovog kvaliteta i upotrebne vrednosti. U skladu sa tim, cilj ovog rada bio je ispitivanje strukturnih i performansnih karakteristika platnene tkanine sastavljene od 90% poliestera i 10% elastana. U tu svrhu sprovedena su fizička, mehanička, površinska i kolorimetrijska ispitivanja, uključujući određivanje površinske mase, debljine, gustine osnove i potke, zateznih svojstava tkanine i prede, propustljivosti vazduha, otpornosti na piling, merenje boje, postojanosti boje pri pranju i postojanosti boje na trljanje. Pored toga, rezultati ispitivanja dostavljeni od strane proizvođača uključeni su u analizu i upoređeni sa laboratorijskim nalazima. Ispitivana tkanina pokazala je generalno povoljne performanse u pogledu strukturnih svojstava, mehaničkog ponašanja, izgleda površine i postojanosti boje. Tokom površinskih ispitivanja nisu uočeni značajna površinska degradacija niti izraženo izbijanje elastanskih vlakana, dok su ispitivanja postojanosti boje pokazala zadovoljavajuću otpornost na pranje i trljanje. Sveukupno, dobijeni rezultati ukazuju da platnena tkanina sa sastavom 90% poliester / 10% elastan poseduje odgovarajuće performansne karakteristike za svoju predviđenu namenu.*

Ključne reči: *Tkanina sa elastanom, mešavina poliester/elastan, platneno tkanje, mehanička svojstva, površinske performanse, postojanost boje*

1. INTRODUCTION

In recent years, fabrics containing elastane have become widely used in the textile industry due to their high stretchability, freedom of movement, and wearing comfort (Shobanasree, Prakash, Kumar, Lokesh, & Manickam, 2022; Gorjanc & Bukošek). Even when elastane fibers are included in the fabric structure at low rates of only 2–3%, they can provide the desired level of elasticity, body conformity, and the ability to return to their original shape after deformation (Geleri, Gürarda, & Çeven, 2021; Senthilkumar, 2011). Therefore, elastane has become an important fiber, especially preferred in casual wear, sportswear and form-fitting garments (Senthilkumar, 2011). The addition of elastane has significant effects on the physical and performance properties of fabrics. Literature reports that fabrics containing elastane have increased gram weight (GSM) and thickness values, and also cause changes in air permeability, pilling behavior, stitch density, bursting strength and tensile properties (Azim, Sowrov, Ahmed, Ul Hasan, & Faruque, 2014; Jovanović, Penava, & Vrljicak, 2022). However, various quality problems such as loss of elasticity, permanent deformation, dimensional changes, pilling, fuzz formation, color change and elastane protrusion from the fabric surface can occur in elastane fabrics during use and maintenance (Bolaji & Dolez, 2024). Among these problems, elastane protrusion is considered a

significant defect that negatively affects the aesthetic appearance and can reduce the mechanical performance and lifespan of the fabric. Therefore, identifying the factors that cause elastane protrusion and examining the effects of this defect on fabric performance is important for improving the quality and durability of elastane-containing textile products.

2. MATERIALS AND METHOD

A plain-woven fabric containing 90% polyester (PES) and 10% elastane was used as the experimental material. The fabric was supplied by DressBest. The fabric is commonly used in uniform manufacturing, and the aim of this study was to evaluate its structural and performance properties. The experimental tests were carried out at the Istanbul Textile Research R&D and Innovation Center of Marmara University. In addition, the test results obtained from DressBest's in-house laboratory evaluations were incorporated into the analysis. As a result of the measurements, the fabric weight was determined as an average of 193 g/m², while the fabric thickness was measured as 0.56 mm. The warp and weft density were determined to be 27 threads/cm.

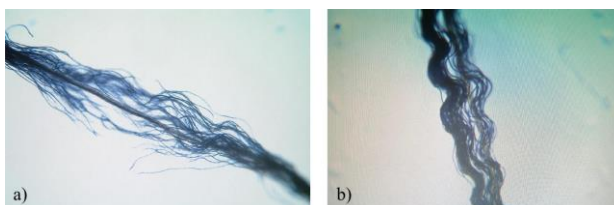


Figure 1: a) Microscopic appearance of the warp yarn b) Microscopic appearance of the weft yarn

2.1 Fabric Tensile Properties

The tensile properties of the fabric samples were determined according to ISO 13934-1. Tests were performed separately in the warp and weft directions, and the obtained breaking strength and breaking elongation values are given in graphical form.

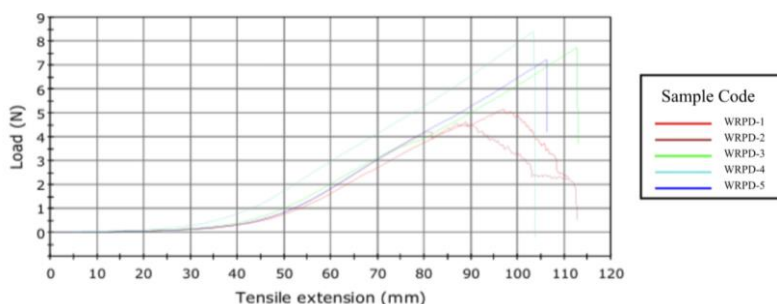


Figure 2: Load–Elongation Behavior of Fabric Samples in the Warp Direction

The graph shows a comparative analysis of the load-elongation behavior of the samples. The samples showed increasing elongation with increasing applied load, and breaking occurred after reaching the maximum load.

Table 1: Tensile Properties of Fabric Samples in the Warp Direction

Sample Code	Maximum Force (N)	Elongation at Break (mm)	Elongation at Maximum Force (%)
WRPD-1	5,17	110,78	48,47
WRPD2	4,63	112,46	44,48
WRPD-3	7,70	112,63	56,31
WRPD-4	8,36	103,62	51,56
WRPD-5	7,23	106,13	53,07
Mean	6,62	109,12	50,78
Maximum	8,36	112,63	56,31
Standard Deviation	1,63	4,04	4,51
CV (%)	24,65	3,71	8,89

The average maximum load value in the warp direction was determined to be 6.62 N, and the average elongation at break was 109.12 mm. The similarity of the elongation at break values indicates that the fabric exhibits similar stretching behavior in the warp direction. The average elongation value of 50.78% at maximum load shows that the fabric exhibits a significant elongation behavior under tensile force depending on its elastane content.

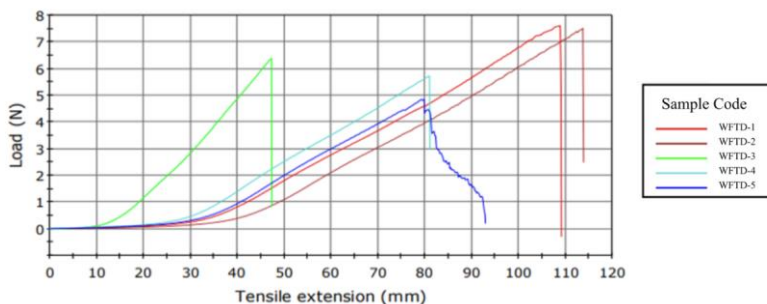


Figure 3: Load–Elongation Behavior of Fabric Samples in the Weft Direction

Table 2: Tensile Properties of Fabric Samples in the Weft Direction

Sample Code	Maximum Force (N)	Elongation at Break (mm)	Elongation at Maximum Force (%)
WRPD-1	7,60	108,96	54,31

WRPD2	7,50	113,61	56,81
WRPD-3	6,38	47,30	23,65
WRPD-4	5,72	80,97	40,40
WRPD-5	4,85	92,80	39,65
Mean	6,41	88,73	42,96
Maximum	7,60	113,61	56,81
Standard Deviation	1,17	26,56	13,33
CV (%)	18.30	29,93	31,03

According to the tensile test results in the weft direction, the average maximum load value was determined as 6.41 N. The average elongation at breaking was obtained as 88.73 mm. The average elongation value at maximum load was determined as 42.96%. Although there is no significant difference in maximum load values between the samples, more significant differences are observed in the elongation at breaking values. In particular, the fact that sample WRPD-3 shows a lower elongation at breaking of 47.30 mm compared to the other samples indicates that the elongation behavior in the weft direction is more variable. When compared with the warp direction results, it is seen that the average maximum load value in the weft direction is at a similar level, but the elongation at breaking value is lower. This situation reveals that the fabric exhibits a more limited and variable elongation behavior under tensile force in the weft direction compared to the warp direction.

2.2 Yarn Tensile Properties

The tensile properties of the warp and warp yarns were evaluated according to ISO 2062.

Table 3: Tensile Properties of Warp Yarns

Sample Code	Maximum Force (N)	Elongation at Break (mm)	Elongation at Maximum Force (%)
1	0,32	65,53	26,11
2	0,30	63,42	25,27
3	0,32	65,51	25,93
4	0,31	66,78	26,61
5	0,32	68,45	27,13
6	0,31	59,78	23,81
7	0,29	58,45	23,28
8	0,32	73,53	29,31
9	0,30	65,61	26,14
10	0,31	72,29	28,64
11	0,31	64,80	25,42
12	0,30	66,10	26,12



13	0,32	65,40	25,75
14	0,31	67,25	26,31
15	0,31	63,95	25,18
16	0,30	66,75	26,10
17	0,32	65,90	25,88
18	0,31	68,10	26,64
19	0,31	64,50	26,38
20	0,30	66,60	28,45
Mean	0,31	65,94	26,22
Maximum	0,32	73,53	29,31
Standard Deviation	0,00887	3,41	1,43
CV (%)	2,87	5,17	5,47

The evaluation of the tensile properties of the warp yarns showed that the maximum force values of the samples were relatively close to each other. This indicates that the warp yarns have similar strength against tensile forces. This result suggests that the yarn structure is generally uniform.

Table 4: Tensile Properties of Weft Yarns

Sample Code	Maximum Force (N)	Elongation at Break (mm)	Elongation at Maximum Force (%)
1	0,31	71,75	28,60
2	0,31	65,61	26,15
3	0,31	71,03	28,31
4	0,32	67,20	26,77
5	0,31	63,42	25,10
6	0,31	67,62	26,79
7	0,32	64,27	25,60
8	0,31	65,62	25,98
9	0,31	65,62	24,95
10	0,32	68,13	26,98
11	0,31	66,40	26,42
12	0,31	67,10	26,70
13	0,32	68,30	27,12
14	0,31	65,85	26,20
15	0,31	66,95	26,55
16	0,32	67,80	26,88
17	0,31	64,90	25,82
18	0,31	66,25	26,34

19	0,32	68,50	27,05
20	0,31	65,40	26,08
Mean	0,31	66,84	26,52
Maximum	0,32	71,75	28,60
Standard Deviation	0,005	2,46	0,96
CV (%)	1,61	3,68	3,62

The tensile test results of the weft yarns showed that the maximum force values of the samples were very similar. This indicates that the weft yarns have similar strength against tensile forces. The results suggest that the weft yarns show a generally uniform structural behaviour.

2.3 Pilling/Martindale Test Results

The pilling resistance of the fabric sample was performed according to ISO 12945-2 using the Martindale method. Following the Martindale test, the fabric sample was evaluated under a light cabinet using a pilling scale. Visual inspection revealed that the pilling degree of the sample was in the range of 4–5. This value indicates that there is negligible pilling and fuzzing on the fabric surface. No significant pilling formation was observed on the fabric surface after the test. Furthermore, no adverse conditions such as elastomer shedding, fraying, or surface deterioration were detected. This result shows that the plain weave fabric with 90% PES / 10% elastane exhibits good surface performance against friction. A pilling degree between 4–5 suggests that the fabric can largely maintain its surface appearance during use. Therefore, the Martindale test result was deemed positive, and the examined fabric sample was evaluated as having a very low tendency to pill.



Figure 4: Martindale Test Results

2.4 Air Permeability Properties of the Fabric

The air permeability test was performed according to ISO 9237. During the measurements, a pressure difference of 25 Pa was applied to the fabric sample, and the average air permeability value was determined as 6 L/min.

2.5 Colour Properties of the Fabric

The measurements were performed using a Datacolor SF 600+ reflectance spectrophotometer. As a result of the measurements, the CIELAB colour coordinates (L^* , a^* , and b^*) of the fabric were obtained.

Table 5: Colour Measurement Results of the Fabric Sample

Sample	L^*	a^*	b^*	C^*	h	X	Y	Z	x	y
Uniform Fabric	20,65	4,75	16,24	16,92	286,31	3,27	3,15	6,72	0,25	0,24

The L value of 20.65 indicates that the fabric has a dark colour appearance. The positive a value shows that the colour is slightly closer to the red axis, while the negative b^* value indicates that the colour is located towards the blue axis. Based on these results, the sample was evaluated as having a dark blue/navy colour characteristic. The C^* value represents the colour saturation, while the h value provides information about the colour hue angle.

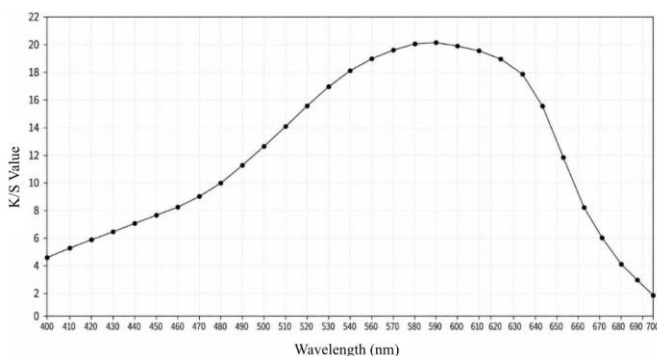


Figure 5: K/S Spectral Analysis of the Fabric Sample

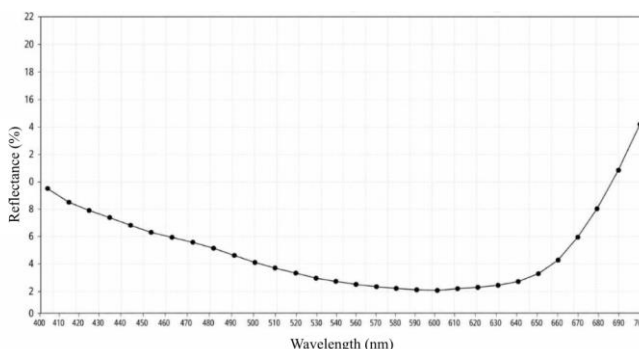


Figure 6: Spectral Reflectance Curve of the Fabric Sample

Examination of the curve shows that the fabric reflects light at different wavelengths. The reflectance values decrease from 400 nm onwards, reach their lowest level in the approximately 590–600 nm range, and then increase again. This indicates that the fabric absorbs more light at certain wavelengths and consequently exhibits a darker color character. The low reflectance values observed in the spectral reflectance curve indicate that the fabric absorbs a significant amount of light. This result is consistent with the low L^* value obtained in the CIELab color measurement and supports the dark blue/navy color character of the fabric.

2.6 Evaluation of Colour Fastness to Laundering

The colour fastness to laundering test was carried out according to ISO 105-C06. The colour change of the sample and the staining on the multifibre fabric were assessed using the grey scale.

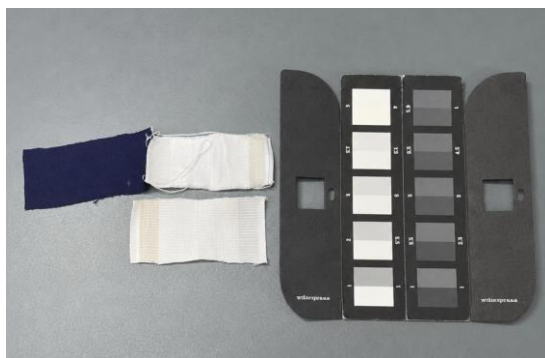


Figure 7: Grey Scale Evaluation of the Sample and Multifibre Fabric After Laundering

According to the gray scale evaluation, the laundering fastness result of the sample can be said to be at a good level. In particular, the absence of significant fading in the blue fabric and the lack of noticeable staining on the multifiber surface indicate that the fabric shows positive color retention against laundering conditions.

2.7 Dry and Wet Rubbing Fastness

Colour fastness testing was performed according to the ISO 105-X12:2016 standard. Both dry rubbing and wet rubbing tests were applied to the sample. The evaluation revealed colour fastness values of 4 for both dry and wet rubbing. This value indicates that very little colour transfer occurred onto the cotton rubbing cloth. Overall, the fabric sample showed good rubbing fastness performance.

2.8 Evaluation of Test Results Provided by Dressbest

The sample was subjected to a pilling resistance test at 2000 revolutions using the Martindale method. The pilling rating was determined as 5, and the fuzzing rating was also determined as 5. According to the evaluation scale, a rating of 5 indicates that no visible



change occurred on the fabric surface. These results indicate that the fabric sample has a very low tendency to pilling and fuzz formation under friction conditions. Obtaining pilling and fuzzing ratings of 5 after 2000 revolutions shows that the fabric maintains its surface appearance and exhibits high resistance to pilling during use. According to the report provided by Dressbest, the pH value of the fabric sample was determined as 7.11 according to the ISO 3071 standard. The reference range in the report is given as 4.5–7.5, and it is seen that the obtained pH value remains within this range. Therefore, the pH test result was evaluated as “PASS”. In the laundering fastness test, the sample and multifiber fabric were examined under a light cabinet with a gray scale, and no significant change in fabric color and no intense staining on the multifiber were observed. In this respect, the company's test result and the observational evaluation obtained in the university laboratory are consistent with each other. According to the test report provided by DressBest, the results for colour fastness to water, acidic perspiration, and alkaline perspiration were found to be in the range of 4 to 4/5. These findings indicate that the fabric does not show significant colour fading under wet use conditions and does not cause considerable dye transfer onto different fibre surfaces. The PASS results obtained in all three evaluations demonstrate that the sample has sufficient colour resistance against water and perspiration effects. The dimensional stability test after steaming showed that the fabric sample had a dimensional change of -1% in the warp direction and -2% in the weft direction. Since both values remained within the reference limit of $\pm 3\%$, the test result was evaluated as PASS. These results indicate that the fabric maintained an acceptable dimensional stability after steam exposure and did not show significant shrinkage or loss of shape.

3. CONCLUSION

In this study, a plain weave fabric sample containing 90% polyester and 10% elastane was evaluated in terms of its physical properties, tensile behaviour, surface appearance, colour characteristics, and fastness performance. When the tests conducted in the university laboratory and the test results provided by DressBest were evaluated together, it was observed that the investigated fabric showed generally acceptable performance and suitability for use. The fabric weight, thickness, warp and weft density, air permeability, and tensile properties revealed the structural characteristics of the fabric, while the colour measurements and fastness tests supported that the fabric had an acceptable performance under usage conditions. In terms of surface performance, no significant elastane protrusion or severe surface damage was observed. However, it was concluded that the elastane protrusion problem is not only associated with the structural properties of the fabric but may also vary depending on user-related factors such as the application area of the product, frequency of use, areas exposed to friction, washing, and care conditions. Therefore, although laboratory test results are important indicators for the quality evaluation of elastane-containing fabrics, actual usage conditions of the product should also be taken into consideration.



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