



FROM TEXTILE WASTE TO HIGH PERFORMANCE: A COMPARATIVE ANALYSIS OF REGENERATED CELLULOSE FIBERS IN WOVEN FABRICS

Scientific paper
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ABSTRACT: The transition toward circular and sustainable textile systems has intensified the need for high-performance materials derived from post-consumer waste streams. In this context, regenerated cellulose fibers such as SaXcell™, produced from recycled cotton textiles, present a promising alternative to conventional and man-made cellulosic fibers. This study aims to systematically investigate the structure–property relationships of woven fabrics manufactured from lyocell fibers from textile wastes (SaXcell™ as brand name), lyocell fibers differing in cellulose sources (Tencel™ and Ecocell™ as brand names, respectively) and cotton fibers, with a particular focus on the influence of cotton/SaXcell™ blend ratios on overall fabric performance. Ring-spun yarns were produced from each fiber type and woven into plain weave fabrics under standardized conditions. The fabrics were characterized in terms of physical, mechanical, thermal and optical properties. All tests were conducted in accordance with relevant ISO standards. The findings reveal that fabrics produced from waste-derived regenerated lyocell fibers exhibited the highest weft-direction tensile strength and higher thermal absorptivity, which can be attributed to their fiber morphology and intermolecular structure. In terms of optical properties, the waste-derived regenerated lyocell fabric exhibited the highest whiteness index, whereas the conventional cotton fabric showed the highest lightness (L^*) value after dyeing, demonstrating differences in optical behavior depending on fiber type and processing stage. The 50/50 cotton/SaXcell™ blend achieves a synergistic balance between mechanical durability, thermal comfort and aesthetic performance. Furthermore, all samples exhibited consistently high color fastness ratings, confirming the compatibility of regenerated fibers with conventional dyeing processes. Overall, this study provides a comprehensive comparative assessment of regenerated cellulose-based woven fabrics and



highlights the potential of SaXcell™ as a viable and sustainable alternative in textile applications, offering critical insights into performance optimization and material selection for eco-efficient fabric design.

Keywords: Sustainable textiles, circular economy, textile recycling, regenerated cellulose fibers, SaXcell™.

OD TEKSTILNOG OTPADA DO VISOKIH PERFORMANSI: UPOREDNA ANALIZA TKANINA OD REGENERISANIH CELULOZNIH VLAKANA U TKANINAMA

APSTRAKT: Prelazak na cirkularne i održive tekstilne sisteme intenzivirao je potrebu za visokop performansnim materijalima dobijenim iz post-potrošačkih tokova otpada. U tom kontekstu, regenerisana celulozna vlakna kao što je SaXcell™, proizvedena od recikliranog pamučnog tekstila, predstavljaju obećavajuću alternativu konvencionalnim i veštačkim celuloznim vlaknima. Ova studija ima za cilj da sistematski istraži odnose strukture i svojstava tkanina proizvedenih od liocel vlakana iz tekstilnog otpada (SaXcell™ kao brend), liocel vlakana koja se razlikuju po izvorima celuloze (Tencel™ i Ecocell™ kao brendovi, respektivno) i pamučnih vlakana, sa posebnim fokusom na uticaj odnosa mešavine pamuk/SaXcell™ na ukupne performanse tkanine. Prstenasto ispredene pređe su proizvedene od svake vrste vlakana i tkane u tkanine platno prepletaja pod standardizovanim uslovima. Tkanine su okarakterisane u pogledu fizičkih, mehaničkih, termičkih i optičkih svojstava. Sva ispitivanja su sprovedena u skladu sa relevantnim ISO standardima. Rezultati pokazuju da tkanine proizvedene od regenerisanih liocel vlakana dobijenih iz otpada pokazuju najveću zateznu čvrstoću u pravcu potke i veću apsorpciju toplote, što se može pripisati njihovoj morfologiji vlakana i intermolekularnoj strukturi. Što se tiče optičkih svojstava, regenerisana liocel tkanina dobijena iz otpada pokazala je najviši indeks beline, dok je konvencionalna pamučna tkanina pokazala najveću vrednost beline (L^*) nakon bojenja, što ukazuje na razlike u optičkom ponašanju u zavisnosti od vrste vlakana i faze obrade. Mešavina 50/50 pamuk/SaXcell™ postiže sinergističku ravnotežu između mehaničke izdržljivosti, termičke udobnosti i estetskih performansi. Štaviše, svi uzorci su pokazali konstantno visoke ocene postojanosti boje, potvrđujući kompatibilnost regenerisanih vlakana sa konvencionalnim procesima bojenja. Sve u svemu, ova studija pruža sveobuhvatnu uporednu procenu tkanina na bazi regenerisane celuloze i ističe potencijal SaXcell™ održive alternative u tekstilnim primenama, nudeći kritične uvide u optimizaciju performansi i izbor materijala za ekološki efikasan dizajn tkanina.

Ključne reči: Održivi tekstil, cirkularna ekonomija, reciklaža tekstila, regenerisana celulozna vlakna, SaXcell™.



1. INTRODUCTION

The textile industry is facing increasing pressure to reduce its environmental footprint due to the intensive consumption of natural resources, high energy demand and the growing accumulation of textile waste. According to recent estimates, global textile fiber demand is expected to increase substantially in the coming decades, while the availability of conventional raw materials such as cotton remains limited. Consequently, the development of sustainable and circular material solutions has become a major research focus within the textile sector [1-4].

Among the various approaches proposed to support a circular textile economy, the recycling of post-consumer textile waste into high-value regenerated fibers has attracted considerable attention. Regenerated cellulosic fibers are regarded as promising alternatives to both conventional cotton and synthetic fibers due to their renewable origin, biodegradability and favorable textile performance characteristics [1,5]. In particular, lyocell fibers produced from regenerated cellulose have gained importance because of their excellent mechanical properties, moisture management behavior and environmental advantages compared with conventional fiber production systems [6].

Recent developments in chemical recycling technologies have enabled the recovery of cellulose from post-consumer cotton textiles and its conversion into regenerated fibers suitable for textile applications. These technologies provide an opportunity to retain the value of textile waste within the production cycle and reduce dependence on virgin raw materials. Life cycle assessment studies have demonstrated that regenerated cellulose obtained through closed-loop recycling processes may significantly reduce environmental impacts compared with conventional cellulose production routes [7]. Furthermore, studies have shown that regenerated fibers produced from cotton waste can achieve mechanical and textile performance comparable to commercially available regenerated cellulosic fibers [4, 8, 9].

Although numerous studies have investigated recycled cotton fibers, regenerated cellulose fibers and textile recycling technologies, existing research has primarily focused on fiber production processes, structural characteristics and general textile performance [1, 9, 10]. Comprehensive investigations evaluating the physical, mechanical, thermal, optical and moisture management properties of woven fabrics produced from regenerated lyocell fibers derived from textile waste remain limited. In particular, studies comparing waste-derived regenerated lyocell fibers with lyocell fibers originating from different cellulose sources and conventional cotton fibers under identical fabric construction conditions are still scarce.

Therefore, the present study aims to comparatively evaluate the performance characteristics of woven fabrics produced from regenerated lyocell fibers derived from post-consumer textile waste, lyocell fibers obtained from different cellulose sources and conventional cotton fibers. Particular attention is given to the influence of regenerated lyocell/cotton blend ratios on fabric performance. The fabrics were characterized in terms of optical, mechanical, thermal and moisture management properties using standardized test methods. By providing a comprehensive assessment of the structure–property



relationships of these fabrics, this study contributes to the understanding of the performance potential of recycled regenerated cellulose fibers and supports their utilization in sustainable and circular textile production systems.

2. EXPERIMENTAL

2.1. Materials

Textile (yarns and fabrics) samples produced from different cellulosic fiber types were investigated in this study. The selected materials included regenerated lyocell fibers obtained from post-consumer cotton textile waste (SaXcell™), lyocell fibers produced from different wood-based cellulose sources (Tencel™ and Ecocell™), conventional cotton fibers, a blend of cotton and regenerated lyocell fibers.

Ring yarns from Tencel™ (Yarn 1), Ecocell™ (Yarn 2), conventional cotton fibers (Yarn 3), a conventional cotton/SaXcell™ blend (Yarn 4), and SaXcell™ (Yarn 5) were used in the study. The yarns were produced using compact spinning technology with a yarn count of Ne 30 and a twist level of 765 T/m. Then, all yarn samples were utilized as weft yarns in the production of plain woven fabrics, whereas a 20-denier recycled polyester monofilament yarn was used as the warp yarn. The fabrics had a sett of 48 × 30 threads/cm (warp × weft) and an areal density of approximately 90 g/m². Following weaving, all samples were subjected to identical bleaching, dyeing and finishing processes.

The constructional parameters and material compositions of the investigated fabrics are presented in Table 1.

Table 1: Structural properties of the woven fabric samples

Sample Code	Fabric Composition (%)	Warp Yarn	Weft Yarn	Warp/Weft Density	Weave Report
Fabric 1	85% Tencel™, 15% Recycled PES	20 Denier Recycled Polyester Monofilament	Yarn 1: 30 Ne Tencel™ Ring Yarn	48 warp/cm 30 weft/cm	Plain Weave
Fabric 2	85% Ecocell™, 15% Recycled PES		Yarn 2: 30 Ne Ecocell™ Ring Yarn		
Fabric 3	85% Cotton, 15% Recycled PES		Yarn 3: 30 Ne Cotton Ring Yarn		
Fabric 4	43% SaXcell™, 42% Cotton, 15% Recycled PES		Yarn 4: 30 Ne 50/50 SaXcell™/Cotton Ring Yarn		
Fabric 5	85% SaXcell™, 15% Recycled PES		Yarn 5: 30 Ne SaXcell™ Ring Yarn		

2.2. Method

The experimental methodology consisted of yarn characterization, fabric production and comprehensive performance evaluation of the woven fabrics.

The physical and mechanical properties of the compact-spun yarns were evaluated prior to fabric production. Yarn evenness properties, including mass variation (CVm%), thin places (-50%/km), thick places (+50%/km), neps (+200%/km), hairiness (H) and hairiness variation (sh), were measured using an Uster Tester 6-S (Switzerland) at a testing speed of



400 m/min and a test duration of 2.5 min. Yarn tensile strength (N) and elongation at break (%) were determined using an Uster Tensorapid (Switzerland) at a testing speed of 400 m/min and a gauge length of 500 mm. All measurements were performed in triplicate. Statistical analyses were performed using one-way ANOVA at a confidence level of 95%. Differences between means were considered statistically significant at $p < 0.05$.

The performance of the woven fabrics was evaluated through physical, mechanical, thermal, optical and moisture management characterization tests.

Optical properties were measured using a Datacolor SF600 Plus-CT spectrophotometer. Whiteness index (CIE and Berger), color coordinates (L^* , a^* , b^*), color strength (K/S), chroma (C^*) and hue angle (h°) values were determined to evaluate the optical behavior of the fabrics.

Color fastness properties were assessed according to internationally accepted standards. Washing fastness, water fastness, perspiration fastness and rubbing fastness tests were carried out according to ISO 105-C06, ISO 105-E01, ISO 105-E04 and ISO 105-X12, respectively.

Mechanical performance was evaluated through tensile strength, seam slippage and pilling resistance tests. Tensile strength was measured according to ISO 13934-2, seam slippage according to ISO 13936-2 and pilling resistance according to ISO 12945-2. Dimensional stability after laundering was determined according to ISO 6330. Fabric mass per unit area was also measured and recorded for each sample.

The morphological characteristics of the fibers were examined using a Hitachi TM3030 Plus Scanning Electron Microscope (SEM). SEM images were obtained to investigate fiber surface morphology, structural uniformity and possible differences arising from cellulose source and recycling route.

The hydrophilicity behavior of the fabrics was evaluated by the vertical wicking method according to DIN 53 924:1997. Fabric specimens measuring 2.5 cm $\times$ 20 cm were immersed to a depth of 10 mm in distilled water and loaded with a weight of 0.69 g. The capillary rise height was recorded after 2, 5, 10, 15, 20, 25 and 30 min.

Thermal comfort properties were measured using an Alambeta instrument. Thermal conductivity, thermal resistance, thermal absorptivity and thermal diffusivity values were determined to evaluate the heat transfer characteristics and thermo-physiological comfort behavior of the fabrics.

The experimental results were comparatively analyzed to determine the influence of cellulose source and fiber composition on the overall performance of the yarn and woven fabrics. Particular attention was given to evaluating the performance of waste-derived regenerated lyocell fibers and identifying sustainable alternatives for eco-efficient textile applications.

3. RESULTS AND DISCUSSION

3.1. Yarn Properties

The average yarn properties of the compact-spun yarns produced from different cellulosic fiber types are presented in Table 2.

Table 2: Average yarn properties

Yarn Code	CVm (%)	Thin Places (-50%/km)	Thick Places (+50%/km)	Neps (+200%/km)	Hairiness (H)	Hairiness Variation (sh)	Tensile Strength (N)	Elongation at Break (%)
Yarn 1	12.23	0.00	10.33	12.00	5.75	1.41	5.67	9.63
Yarn 2	11.40	0.00	6.00	9.33	6.80	1.70	4.70	7.80
Yarn 3	11.01	0.00	7.67	3.67	4.18	0.87	3.69	5.70
Yarn 4	12.76	52.33	23.27	26.67	4.01	1.03	4.09	7.09
Yarn 5	10.18	0.00	6.67	25.83	3.64	0.78	3.56	4.52

The yarn evenness results revealed that the raw material type significantly affected yarn quality. The lowest unevenness value was obtained for the yarn produced from regenerated lyocell fibers derived from post-consumer textile waste (Yarn 5) (10.18% CVm), indicating a highly homogeneous yarn structure. In contrast, the regenerated lyocell/cotton blended yarn (Yarn 4) exhibited the highest unevenness value (12.76% CVm), which may be attributed to differences in fiber morphology and physical characteristics between the two fiber types. Statistical analysis confirmed that the effect of raw material on yarn unevenness was significant ($p < 0.05$). Hairiness results also showed a significant dependence on fiber type. The lowest hairiness value was observed for the yarn produced from waste-derived regenerated lyocell fibers (Yarn 5) ($H = 3.64$), followed by the regenerated lyocell/cotton blend (Yarn 4) ($H = 4.01$). In contrast, the highest hairiness value was obtained for one of the wood-based regenerated lyocell yarns (Yarn 2) ($H = 6.80$). Lower hairiness values are generally associated with improved yarn compactness and reduced fiber protrusion from the yarn surface. Statistical analysis indicated significant differences among the yarn types ($p < 0.05$). The tensile strength results demonstrated clear differences among the investigated yarns. The highest tensile strength was obtained for the wood-based regenerated lyocell yarn (Yarn 1) (5.67 N), followed by the second wood-based regenerated lyocell yarn (Yarn 2) (4.70 N). The yarn produced from waste-derived regenerated lyocell fibers (Yarn 5) exhibited a tensile strength of 3.56 N, which was statistically comparable to that of conventional cotton yarns (Yarn 3) (3.69 N). Interestingly, blending regenerated lyocell fibers with cotton improved tensile strength to 4.09 N, indicating a positive contribution of cotton fibers to yarn cohesion and load-bearing capacity. The elongation results followed a trend similar to tensile strength. The highest elongation at break was observed for the wood-based regenerated lyocell yarn (Yarn 1) (9.63%), while the waste-derived regenerated lyocell yarn exhibited the lowest elongation value (Yarn 5) (4.52%). The regenerated lyocell/cotton blend (Yarn 4) exhibited an elongation at break of 7.09%, which was higher than those of both the conventional cotton yarn (Yarn 3, 5.70%) and the pure waste-derived regenerated lyocell yarn (Yarn 5, 4.52%), but lower than those of the wood-based regenerated lyocell yarns (Yarn 1, 9.63% and Yarn 2, 7.80%).

These findings suggest that blending may provide a favorable balance between strength and extensibility. Overall, the yarn characterization results indicate that regenerated lyocell fibers obtained from post-consumer textile waste can be successfully processed on

conventional compact spinning systems and produce yarns with acceptable quality characteristics. Furthermore, blending recycled regenerated fibers with cotton appears to improve certain mechanical properties while maintaining low hairiness and satisfactory yarn uniformity.

3.2. Fiber and Fabric Morphology

SEM images of the woven fabrics at different magnifications are presented in Fig 1. All samples exhibited a regular plain weave structure without visible structural defects. At higher magnifications, the fabrics produced from regenerated lyocell fibers showed smoother and more uniform fiber surfaces compared to the conventional cotton fabric. The fabric produced from regenerated lyocell fibers derived from post-consumer textile waste (Fabric 5) exhibited a morphology comparable to those of the wood-based lyocell fabrics (Fabrics 1 and 2), indicating that the recycling process did not adversely affect fiber structure. The blended fabric (Fabric 4) displayed intermediate morphological characteristics between cotton and regenerated lyocell fibers. The smooth and homogeneous fiber surfaces observed for the regenerated lyocell fabrics are consistent with the lower yarn hairiness and improved yarn uniformity results obtained in this study (Tab 2).

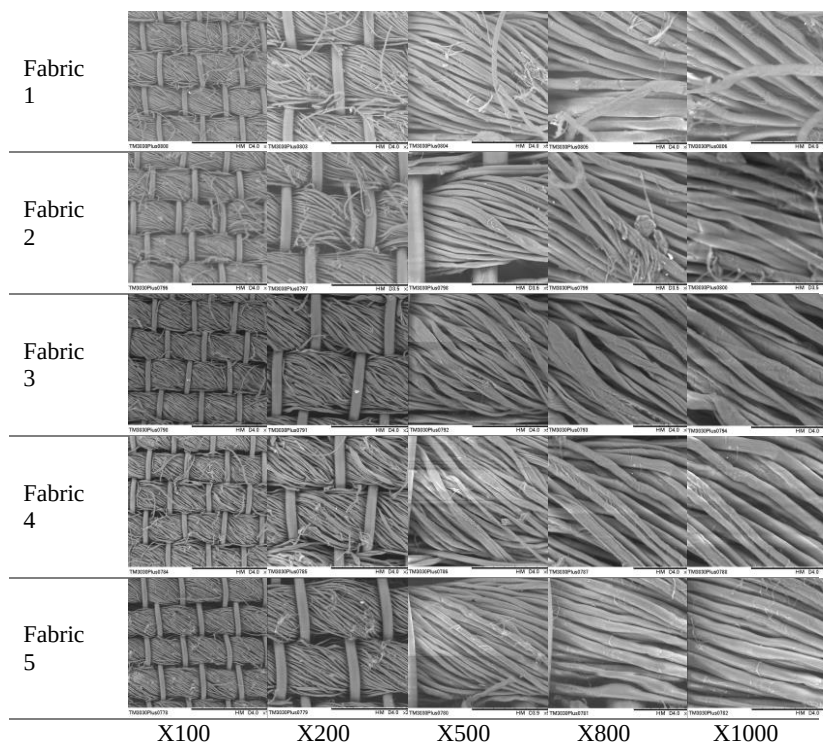


Figure 1: SEM micrographs of woven fabrics produced from different cellulose sources at magnifications of $\times 100$, $\times 200$, $\times 500$, $\times 800$ and $\times 1000$.



Overall, the SEM observations confirm the suitability of recycled regenerated cellulose fibers for high-performance woven textile applications.

3.3. Optical Properties and Color Performance

The whiteness measurements of the greige fabrics revealed significant differences among the investigated cellulosic fiber types. As shown in Table 3, the regenerated lyocell fiber obtained from textile waste (Fabric 5) exhibited the highest Berger whiteness value (28.19) and CIE whiteness index (19.64), whereas conventional cotton fabrics (Fabric 3) showed the lowest whiteness values.

Table 3: Whiteness properties of greige fabrics

Sample Code	Berger Whiteness	CIE Whiteness
Fabric 1	24.02	14.20
Fabric 2	25.03	15.37
Fabric 3	21.99	10.56
Fabric 4	23.04	11.96
Fabric 5	28.19	19.64

The higher whiteness values obtained for Fabric 5 may be attributed to the purification and dissolution stages involved in the chemical recycling process, resulting in a more homogeneous cellulose structure. Similar observations have been reported for regenerated cellulose fibers derived from textile waste.

In Table 4, color measurements performed after dyeing showed that cotton fabrics exhibited the highest lightness value ($L^*=63.47$), while regenerated fiber fabrics produced darker shades under identical dyeing conditions. The cotton/regenerated cellulose fibers derived from textile waste blend displayed intermediate color characteristics between pure cotton and pure regenerated fiber fabrics.

The color strength (K/S) results demonstrated that the highest color strength value was obtained for the fabric produced from wood-based regenerated lyocell fibers ($K/S = 1.63$), followed by the fabric produced from another wood-based regenerated lyocell fiber type ($K/S = 1.52$) and the fabric produced from regenerated lyocell fibers derived from post-consumer textile waste ($K/S = 1.45$). On the other hand, blending conventional cotton fibers with regenerated lyocell fibers derived from post-consumer textile waste increased the K/S value from 0.90 to 1.11, indicating improved color yield and dyeability compared with the 100% cotton fabric.

Table 4: CIELAB color coordinates and color strength (K/S) values of samples

Sample Code	L^*	a^*	b^*	C^*	h°	K/S
Fabric 1	57.28	4.27	7.67	8.78	60.90	1.52
Fabric 2	56.37	4.22	7.28	8.41	59.88	1.63

Sample Code	L*	a*	b*	C*	h°	K/S
Fabric 3	63.47	6.57	5.92	8.84	42.00	0.90
Fabric 4	60.71	5.28	5.84	7.87	47.87	1.11
Fabric 5	57.69	4.07	7.33	8.39	60.96	1.45

As shown in Figure 2, the waste-derived regenerated lyocell fabric exhibited the highest whiteness index among the investigated samples, while the conventional cotton fabric showed the lowest value. The lyocell fibers originating from wood-based cellulose sources achieved the highest color strength values, indicating superior dye uptake under identical dyeing conditions. The waste-derived regenerated lyocell fabric demonstrated color yield values comparable to those of the wood-based lyocell fabrics, confirming its suitability for conventional coloration processes. These results suggest that the cellulose source influences both optical appearance and dyeability; however, regenerated cellulose fibers generally exhibit superior color performance compared to conventional cotton fibers.

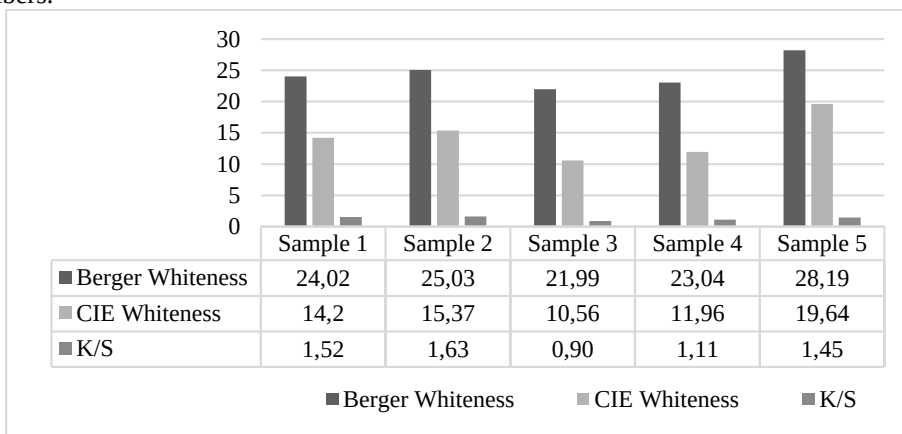


Figure 2: Comparison of CIE whiteness index and color strength (K/S) values of samples

3.4. Color Fastness Properties

The color fastness performance of the dyed woven fabrics was evaluated in terms of washing, water, acidic perspiration, alkaline perspiration and rubbing fastness according to the relevant ISO standards. The results are summarized in Table 5.

Table 5: Color fastness properties of the samples

Sample Code	Washing Fastness	Water Fastness	Acid Perspiration Fastness	Alkaline Perspiration Fastness	Dry Rubbing Fastness	Wet Rubbing Fastness
Fabric 1	4-5	4-5	4-5	4-5	4-5	4-5
Fabric 2	4-5	4-5	4-5	4-5	4-5	4-5
Fabric 3	4-5	4-5	4-5	4-5	4-5	4-5
Fabric 4	4-5	4-5	4-5	4-5	4-5	4-5
Fabric 5	4-5	4-5	4-5	4-5	4-5	4-5

As shown in Table 5, all investigated fabrics exhibited excellent color fastness performance. Washing, water, acidic perspiration, alkaline perspiration and rubbing fastness ratings were consistently evaluated as 4–5 for all samples, regardless of fiber type or cellulose source.

The results indicate that fabrics produced from waste-derived regenerated lyocell fibers, wood-based lyocell fibers and conventional cotton fibers can be successfully dyed using conventional coloration processes without compromising fastness performance. No significant differences were observed among the samples in terms of staining or color change behavior after washing, water exposure, perspiration or rubbing tests.

3.5. Physical and Mechanical Properties

The physical and mechanical test results are presented in Table 6. All fabrics exhibited good dimensional stability after laundering, with shrinkage values generally below 2%, indicating satisfactory dimensional performance regardless of fiber composition. Pilling resistance ratings ranged between 4 and 5, indicating excellent surface durability for all samples.

The tensile strength results showed notable differences among fiber types. The highest weft-direction tensile strength was observed for the fabric produced from regenerated lyocell fibers derived from post-consumer textile waste (215.07 N), followed by conventional cotton fabric (199.74 N), fabrics produced from wood-based lyocell fibers (194.22 N and 186.72 N, respectively). These results suggest that the regenerated cellulose fiber derived from textile waste possesses a highly efficient load-bearing structure. The relatively low weft-direction tensile strength of the blended fabric may be attributed to the interaction of fibers with different morphological and mechanical characteristics within the yarn structure.

In the warp direction, cotton fabrics exhibited the highest tensile strength (229.86 N), while the fabric produced from the cotton/regenerated lyocell blend showed the second highest value (213.48 N). The blend fabric demonstrated a balanced performance in both directions, indicating a synergistic interaction between cotton and regenerated cellulose fibers derived from textile waste.

Table 6: Mechanical properties of fabrics

Sample Code	Tensile Strength Weft (N)	Tensile Strength Warp (N)	Seam Slippage Warp (mm)	Seam Slippage Weft (mm)
Fabric 1	186.72	164.93	3.45	4.44
Fabric 2	194.22	197.54	3.12	3.46
Fabric 3	199.74	229.86	3.14	3.29
Fabric 4	108.28	213.48	3.24	4.51
Fabric 5	215.07	200.92	3.16	3.51

3.6. Thermal and Hydrophilicity Properties

As presented in Table 7, the thermal comfort properties of the investigated fabrics were significantly influenced by fiber composition and cellulose source. Among the tested samples, the conventional cotton fabric exhibited the highest thermal conductivity value (19.47×10^{-3} W/mK), whereas fabrics produced from regenerated cellulose fibers generally showed lower thermal conductivity values. However, the differences between the samples were relatively small, indicating comparable heat transfer characteristics.

The most notable variation was observed in thermal absorptivity. According to Table 7, the fabric produced from regenerated lyocell fibers derived from post-consumer textile waste exhibited the highest thermal absorptivity value ($251.97 \text{ Ws}^{1/2}/\text{m}^2\text{K}$), followed by the regenerated lyocell/cotton blend ($234.13 \text{ Ws}^{1/2}/\text{m}^2\text{K}$). Since higher thermal absorptivity values are associated with a cooler sensation during initial skin contact, these fabrics are expected to provide enhanced thermo-physiological comfort, particularly in warm-weather clothing applications. The results therefore suggest that waste-derived regenerated lyocell fibers can contribute positively to the development of sustainable fabrics with improved cooling performance.

Table 7: Thermal properties of samples

Sample Code	Thermal Conductivity ($\times 10^{-3}$ W/mK)	Thermal Diffusivity ($\times 10^{-6}$ m ² /s)	Thermal Absorptivity ($\text{Ws}^{1/2}/\text{m}^2\text{K}$)	Thermal Resistance ($\times 10^{-3}$ Km ² /W)	Heat Flow Density (W/m ²)
Fabric 1	18.60	0.00767	212.60	11.97	436.40
Fabric 2	18.70	0.00800	213.47	12.10	437.27
Fabric 3	19.47	0.00800	222.97	11.53	440.27
Fabric 4	18.80	0.00667	234.13	11.57	439.40
Fabric 5	18.47	0.00533	251.97	11.20	462.03

The hydrophilicity performance of the woven fabrics was evaluated using the vertical wicking method and the results are presented in Figure 3. The wicking height increased with increasing test duration for all samples, indicating continuous capillary water transport through the fabric structure.

As shown in Figure 3, the fabric produced from conventional cotton fibers exhibited the highest wicking performance throughout the entire test period. After 30 minutes, the cotton fabric reached a wicking height of 8.30 cm, demonstrating its superior moisture transport capability. This behavior can be attributed to the natural hydrophilic structure of cotton fibers and their ability to rapidly absorb and transport liquid water through capillary action. The fabric produced from the blend of regenerated lyocell fibers derived from post-consumer textile waste and cotton fibers exhibited the second-highest wicking performance, reaching a height of 7.40 cm after 30 minutes. The improved liquid transport behavior of the blended fabric suggests that the incorporation of cotton fibers positively contributes to moisture movement within the fabric structure.

The fabrics produced from lyocell fibers originating from different cellulose sources exhibited similar wicking characteristics, with final wicking heights ranging between 6.53 and 6.90 cm after 30 minutes. Among these samples, the fabric produced from wood-based regenerated lyocell fibers showed slightly higher liquid transport performance than the fabrics produced from waste-derived regenerated lyocell fibers. However, the differences were relatively small, indicating comparable hydrophilic behavior.

The average wicking heights calculated over the entire test period were 6.62 cm for conventional cotton, 5.99 cm for the regenerated lyocell/cotton blend, 5.62 cm and 5.37 cm for the wood-based regenerated lyocell fabrics and 5.26 cm for the waste-derived regenerated lyocell fabric. These results indicate that although the conventional cotton fabric exhibited the highest wicking performance, all regenerated lyocell fabrics reached wicking heights exceeding 6.5 cm after 30 min, indicating effective moisture transport behavior.

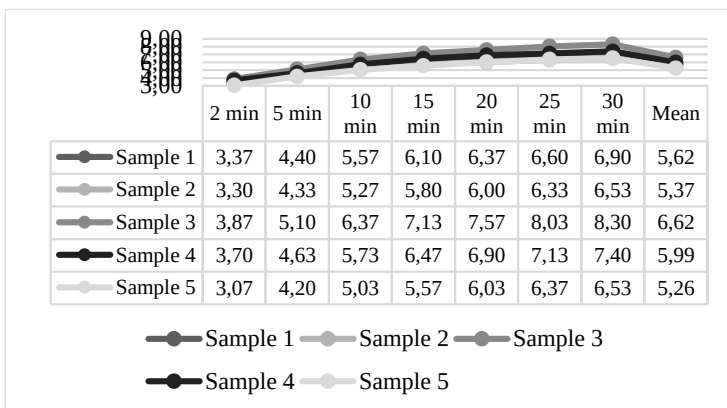


Figure 3: Vertical wicking height versus time for samples

4. CONCLUSION

This study presented a comprehensive comparison of woven fabrics produced from conventional cotton fibers, wood-based regenerated lyocell fibers and regenerated lyocell fibers derived from post-consumer textile waste. The results demonstrated that the source



of cellulose significantly influences the optical, mechanical, thermal and moisture management performance of woven fabrics.

The fabrics produced from regenerated lyocell fibers obtained through textile waste recycling exhibited performance characteristics comparable to, and in some cases superior to, those of conventional cotton and wood-based regenerated lyocell fibers. In particular, the waste-derived regenerated lyocell fabric showed the highest weft-direction tensile strength and thermal absorptivity values among the investigated samples. These results indicate that the chemical recycling process can generate regenerated cellulose fibers with excellent structural integrity and favorable thermo-physiological comfort properties.

The color measurement results further revealed that regenerated lyocell fibers exhibited high dye affinity and color yield, while all samples demonstrated excellent washing, water, perspiration and rubbing fastness properties. This confirms that recycled regenerated cellulose fibers can be successfully integrated into existing dyeing and finishing processes without compromising product quality.

Although conventional cotton fabrics exhibited the highest moisture transport performance, fabrics containing regenerated lyocell fibers also provided satisfactory hydrophilicity characteristics. Furthermore, the cotton/regenerated lyocell blend displayed a balanced combination of tensile performance, thermal comfort, moisture management and color properties, demonstrating the potential benefits of blending recycled regenerated fibers with conventional natural fibers.

SEM observations revealed that the regenerated lyocell fibers derived from textile waste possessed a smooth and homogeneous surface morphology comparable to that of commercially available regenerated cellulose fibers. These morphological characteristics were found to be consistent with the favorable yarn quality, mechanical performance and comfort-related properties obtained throughout the study.

Overall, the morphological, mechanical and thermal performance results collectively demonstrate that regenerated lyocell fibers derived from textile waste can achieve performance levels comparable to commercially available regenerated cellulose fibers, supporting their potential for large-scale industrial implementation. The findings confirm that regenerated lyocell fibers produced from post-consumer textile waste represent a viable and sustainable alternative to conventional and wood-based cellulosic fibers. The high performance achieved by the recycled regenerated fibers highlights their potential for high-value textile applications while supporting circular economy principles, reducing textile waste and contributing to more resource-efficient and environmentally responsible textile production systems.

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