Enhancing Color Fastness in Upholstery Fabrics: A Comprehensive Analysis of Multifunctional Properties in Woven Fabrics with Varied Fiber Blend Ratios

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Abstract:
This study investigates the multifunctional properties of woven fabrics composed of varying blend ratios of cotton, flax, modal, bamboo, and lyocell fibers, focusing on their impact on upholstery fabrics. The research assesses the K/S colorfastness, color fastness to washing, color fastness to rubbing, and pH levels of these woven fabrics made from different combinations of the aforementioned yarns. Standardized testing methods were employed, and the results were statistically analyzed and compared across different fabric compositions. The study revealed that the inclusion of lyocell yarns significantly enhanced the color fastness properties of upholstery fabrics. The effectiveness of fabric colorfastness was observed to be influenced by the ratios of weft yarn fiber content and specific fabric properties. Furthermore, these effects were closely linked to the structural characteristics of lyocell, including its composition and cross-sectional properties.

Keywords: Modal, Bamboo, Lyocell, Colorfastness.

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The research problem is as follows:

- Difficulty in predicting the impact of the polymeric structure variation of cellulose fibers on the material's saturation level during the dyeing process.
- Suboptimal utilization of certain structural variables in fabrics and some treatment processes to achieve color and aesthetic values resulting from dyeing or printing processes.
- Achieving consumer comfort by using natural cellulose threads instead of common blends (cotton/polyester or viscose/polyester, etc.) and obtaining the desired color effects through dyeing or printing with one or two colors. Additionally, obtaining color effects for the produced fabrics while maintaining the appropriate aesthetic and functional properties for the final consumer use.

Research Objectives:

1. Utilizing the multiple functional properties suitable for the final use of cellulose fibers, whether natural or transformed, which result in various color shades during the dyeing or printing process to achieve color, functional, and aesthetic properties that meet the changing needs of consumers.
2. Reducing production costs for upholstery fabrics.
3. Achieving consumer comfort through different and diverse cellulose materials.
4. Achieving aesthetic aspects in upholstery fabrics by using different and diverse cellulose materials.

Research Hypotheses:

Using cellulose threads with different counts and ratios in the design and production of upholstery fabrics will affect the aesthetic and functional properties of the product.

Research Limits:

Cellulose-based threads (such as linen, cotton, mercerized cotton, lyocell, and bamboo, modal, viscose) are used in different arrangements in the weft for upholstery fabrics.

Research Methodology:

This research relies on an experimental and analytical methodology.

Introduction

Tencel (lyocell) stands as a remarkable regenerated cellulosic fiber. (Ali& Sarwar,2010) derived from bleached wood pulp. (Ozdemir,2017, Badr& Hassanin& Moursey,2016) Its properties closely resemble those of other cellulosic fibers such as ramie, linen, and cotton. (A & El-Banna, 2019), (Prakash et al.,2019) Demonstrating exceptional absorbency, softness, and robustness in both wet and dry conditions, Tencel (lyocell) also boasts resistance against wrinkles (Kaur et al, 2019), (Badr et al., 2016). In contrast, modal exhibits an approximately 50% higher hygroscopic nature per unit volume compared to cotton. (Demiryürek& Kılıç,2018), (Ragghi&Prabhu,2017) Designed to dye akin to cotton, modal retains color fastness even after multiple washes in warm water, maintaining its absorbent, soft, and supple qualities (Ragghi&Prabhu,2017)

Lyocell's manufacturing process yields a molecular fiber orientation predominantly aligned along the fiber axis. (Ali& Sarwar,2010), resulting in a crystallization degree surpassing 90%. (Ozdemir, 2017)Consequently, lyocell exhibits notably high tenacity compared to other regenerated cellulose fibers (Demiryürek& Kılıç, 2018), (Ragghi&Prabhu, 2017). Its crystallization degree surpasses modal by 16% and viscose fiber by 43%, while sharing comparable moisture content, strength, and functional group (-OH) similarities with cotton (A & El-Banna,2019), (Gun& Tiber, 2011). Moreover, lyocell showcases dry strength approaching that of polyester and retains 85% of its strength even when wet (Ragghi&Prabhu ,2017). Under specific conditions, lyocell fibers exhibit fibrillation. (Syed،2010), enabling fabric development with diverse aesthetics, although non-fibrillating versions are also available (Ozdemir,2017). Its usage primarily extends to apparel fabrics, particularly outerwear, but its fibrillating property opens avenues for intriguing nonwoven fabric possibilities (Abdul Basit et al., 2018).

In comparing bamboo fibers with 100% cotton fibers, studies emphasize the structural variances. (A & El-Banna,2019), (Badr et al.,2016)Bamboo fibers showcase a non-circular lobed surface structure, featuring numerous grooves and perforations. (Kaur et al., 2019)While the bamboo fiber's degree of polymerization. And crystallinity ratio is lower than those of cotton fibers, it maintains favorable properties (Prakash et al. ,2019), (Manickavasagam& Ramnath& Elanchezhian, 2015).

Research assessing knitted fabrics from bamboo and cotton fibers showcases comparable wash and rubbing fastness. (Kaur et al., 2019) Notably, bamboo fabrics demonstrate superior light fastness. When compared to cotton fabrics, contributing to their potential in various textile applications (Erdumlu& Ozipek 2008).

Experimental

Materials

The experimentation involved the utilization of upholstery fabrics dyed using a one-step reactive dyeing process. These fabrics were employed to assess both the color strength and wettability across various cellulosic yarns and weft yarns crafted from diverse fiber compositions. The warp of samples consisted of yarn count 150/36 polyester. Constructional parameters of the upholstery fabrics are detailed in Table 1.

[Table 1]: Materials and yarn count of Wefts.

Yarn specifications Characteristic (Materials)	Yarn count
Cotton	30/1ne
Flax (Linen)	24/1 m = 16/1ne
Modal	24/1ne
Bamboo	30/1ne
Lyocell (Tencel)	30/1ne

[Table 2]: Constructional Parameters of Upholstery Fabrics.

No.	Density /cm	Warp yarn rate in fabric	Picks /cm Finished	Weft yarn rate in fabric %					Cover Factor	Materials Percentage in weft content
				Cotton 30/2 Ne	Flax 16/1 Ne	Modal 24/1Ne	Bamboo 30/1Ne	Lyocell 30/1 Ne		
1	72	49	35	51	---	---	---	---	9.97	100%cotton
2	68	47	34	---	53	---	---	---	9.24	100%Flax
3	68	61	34	---	---	39	---	---	9.11	100% Modal
4	72	69	35	---	---	---	31	---	7.51	100% Bamboo
5	72	65	33	---	---	---	---	35	7.51	100% Lyocell
6	71	48	33	26	26	---	---	---	9.83	50% Cotton: 50% Flax
7	72	55	34	29	---	16	---	---	9.21	60%cotton: 40%modal
8	72	59	32	27	---	---	---	14	9.06	70%cotton: 30% lyocell
9	72	61	34	26	---	---	13	---	9.08	60%cotton: 40%bamboo
10	71	48	33	26	26	---	---	---	9.83	50%cotton:50%flax
11	72	55	34	29	---	16	---	---	9.21	60%cotton: 40%modal
12	72	59	32	27	---	---	---	14	9.06	60%cotton: 40%lyocell
13	72	61	34	26	---	---	13	---	9.08	70%cotton:30%bamboo
14	72	55	34	---	30	15	---	---	9.30	70%flax: 30%modal
15	72	56	32	---	29	---	15	---	9.22	70%flax:30%bamboo
16	72	59	32	---	27	---	---	14	9.23	60%flax:30%lyocell
17	72	62	34	---	---	19	19	---	9.01	50%modal:50bamboo
18	73	68	34	---	---	16	---	16	8.84	50%modal:50%lyocell
19	72	66	34	---	---	---	17	17	7.59	50%bamboo:50% lyocell

Dyeing Method

Dyeing of cotton fabric was executed using reactive dye (reactive blue 195). The dyeing process involved dissolving 2% (owf) dye in distilled water, immersing 5g cotton fabrics in the dye solution at a material to liquor ratio of 1:50. post-dyeing, the dyed samples underwent rinsing with tap water, followed by soaping in a 2% nonionic detergent bath at 60°C. Subsequently, the samples were rinsed again. (Smith,2023)

Colorimetric measurements

Color strength (K/S) and Color data CIE LAB space.

The color strength (K/S) in the visible region of the spectrum (400-700) nm was calculated based on:

$$K/S = \frac{(1-R)}{2R} - \frac{(1-R_0)}{2R_0}$$

R = Decimal fraction of the reflectance of PP dyed fabric.
R0= Decimal fraction of the reflectance of the un-dyed fabric.
K = Absorption coefficient.
S = Scattering coefficient.
The colorimetric properties of PP dyed fabrics were obtained with Hunter Lab DP-9000 Color- Spectrophotometer.
The total difference CIE (L*, a*, b*) was measured using the Hunter-Lab spectrophotometer (model: Hunter Lab DP-9000).
CIE (L*, a*, b*) between two colors each given in terms of L*, a*, b* is calculated from:
L* value indicates lightness, (+) if the sample is lighter than standard, (-) if darker.
a* & b* values: indicate the relative positions in the CIE Lab space of the sample and the standard, from which some indication of the nature of the difference can be seen.air-dried at room temperature. (Gupta, 2024)

Fastness properties (Methods, 1990)

Color fastness to washing.

Determined following ISO 105-C02 (1989), involving composite specimens immersed in an aqueous solution containing 5g/l non-ionic detergents at a liquor ratio of 1:50, thermostatically adjusted to 50°C for 30 minutes. Evaluation was conducted using a grey scale for color change. (Lee,2023)

Color fastness to rubbing.

Performed according to ISO 105-X12 (1987), assessing color transfer from colored fibers to other surfaces by rubbing, both on dry and wet fibers. (Patel,2024)

Dry crocking test

The test specimen was placed flat on the base of the crock-meter. A white testing cloth was mounted. The covered finger was lowered on to the test specimen and caused to slide back and forth 20 times by making ten complete turns at a rate of 1 turn/s. The white test sample was then removed for evaluation using the grey scale for staining. (Chen,2023)

Wet crocking test

In the wet crocking test, the white test sample was fully wetted using water to approximately 65% moisture retention and then lifted. The procedure was conducted in a manner similar to the dry crocking test. After completion, the wet white test samples were allowed to air dry before undergoing evaluation. (Smith,2024)

Color fastness to perspiration.

Utilized acidic and alkaline solutions per ISO 105-E04 (1989), evaluating the effect on colored specimens after immersion and vertical placement in an oven at 37°C for 4 hours. (Gupta,2023)

PH level

Quantitative determination of pH in wet processed textiles was carried out using a pH meter after collecting a water extract from the specimen previously boiled in distilled or deionized water. (Lee,2024)

Wettability of cotton and flax with regenerated fabrics

The absorbency and wettability of different fabrics were determined following AATCC test methods (BS 3424), assessing the time for water drop penetration and measuring water height reached in fabric samples. (Patel,2023)

Dyeing and K/S analysis of cotton and flax with regenerated fabrics

The dye ability of various woven fabrics was investigated using reactive dyes, and colorimetric data from reactive dyed fabrics were determined by AATCC Test Method -13523 using a Data color SF 600 plus spectrophotometer interfaced to a PC. (Smith,2024)

[Table 3] indicate the results of samples.

No.	Cover Factor	Wettability, time, seconds (Sinking Method)	K/S Color: Blue	Colorfastness to Crocking		Color Fastness to Laundering							PH Level PH Meter	Materials Percentage in weft content
				Dry state	Wet state	Change of Color	Wool	Acrylic	Polyester	Nylon	Cotton	Acetate		
1	9.97	2.26	9.65	3	2	4	4	4-5	4-5	4-5	4-5	4	7.77	100%cotton
2	9.24	3.03	7.11	3	1-2	4-5	3-4	4-5	4-5	4-5	4-5	4	7.87	100%Flax
3	9.11	1.83	11.84	3-4	2-3	4-5	3-4	4	3-4	4	3-4	4	7.83	100% Modal
4	7.51	1.59	12.17	4	3	4-5	4	4-5	4-5	4-5	4-5	4	8.56	100% Bamboo
5	7.51	1.6	14.34	4	2	4-5	3-4	4	4	4-5	4-5	4-5	8.26	100% Lyocell
6	9.83	2.63	9.81	3-4	1-2	4-5	3-4	4	4-5	4-5	4	4	7.06	50% Cotton: 50% Flax
7	9.21	2.3	11.2	4	3	4-5	4	4-5	4-5	4-5	4-5	4-5	7.49	60%cotton: 40%modal
8	9.06	2.4	12.95	4-5	2-3	4-5	3-4	4-5	4-5	4-5	4-5	4	7.69	70%cotton: 30% lyocell
9	9.08	2.5	11.19	4	2	4-5	3	4-5	4-5	4-5	4-5	4	7.91	60%cotton: 40%bamboo
10	9.83	2.63	9.81	3-4	1-2	4-5	3-4	4	4-5	4-5	4	4	7.06	50%cotton:50%flax
11	9.21	2.3	11.2	4	3	4-5	4	4-5	4-5	4-5	4-5	4-5	7.49	60%cotton: 40%modal
12	9.06	2.4	12.95	4-5	2-3	4-5	3-4	4-5	4-5	4-5	4-5	4	7.69	60%cotton: 40%lyocell
13	9.08	2.5	11.19	4	2	4-5	3	4-5	4-5	4-5	4-5	4	7.91	70%cotton:30%bamboo
14	9.30	2.64	9.66	3-4	2	4-5	3-4	4-5	4	4-5	3	4	7.73	70%flax: 30%modal
15	9.22	1.99	8.32	4	2	4-5	3-4	4-5	4-5	4-5	4-5	4	8.67	70%flax:30%bamboo
16	9.23	1.7	8.12	4	2	4-5	3	4-5	4-5	4-5	4-5	4-5	8.67	60%flax:30%lyocell
17	9.01	1.83	10.86	4	3	4-5	4	4-5	4-5	4	4-5	4-5	8.87	50%modal:50bamboo
18	8.84	1.8	12.17	4	2-3	4-5	4	4-5	4-5	4-5	4-5	4	8.96	50%modal:50%lyocell
19	7.59	1.83	11.57	4	3-4	4-5	4	4-5	4-5	4	4-5	4	9.1	50%bamboo:50% lyocell

Results and Discussions

Properties of different cellulosic fabrics

Table (3) exhibits the physical properties, including wettability, K/S color strength, pH level, and mean drape coefficient of woven fabrics composed of various cellulosic materials:

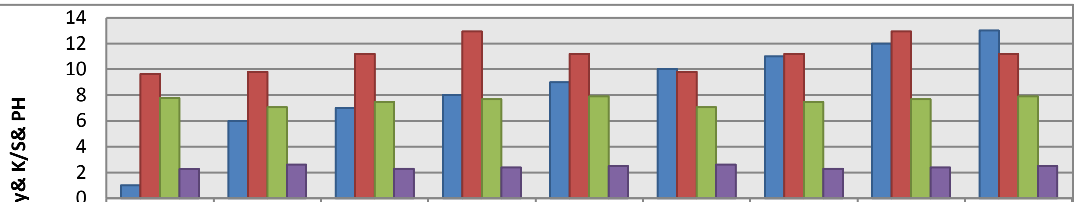
1. **Wettability**: Bamboo fabric shows higher wettability (1.59 seconds), while lyocell fabric demonstrates superior wettability (1.6 seconds) in the weft direction compared to flax fabric. Flax fabric, however, exhibits lower wettability (3.3 seconds).
2. **K/S Color Strength**: Lyocell fabric displays higher K/S color strength (14.34) compared to flax fabric (7.11).
3. **PH Levels**: Bamboo (8.56) and lyocell (8.26) fabrics have higher pH values compared to modal, flax, and cotton fabrics.
4. **Color Fastness to Crocking and Laundry**: Modal, lyocell, and bamboo fabrics show better results in color fastness to crocking and laundry compared to cotton and flax fabrics. Especially in color fastness to laundry, modal, lyocell, and bamboo fabrics excel.
5. **Dry State Crocking**: Modal, lyocell, bamboo, and cotton fabrics exhibit higher results in dry state crocking. However, cotton fabric experiences a loss in color change in this aspect. The information provided helps in understanding the comparative strengths and weaknesses of these different cellulosic fabrics based on their physical properties and performance in different tests related to color fastness and wettability.

Wettability, Color Strength (K/S), and pH Level of Cotton Fabrics with Different Percentages

It appears that Figure 1 and the accompanying analysis provide information on wettability, color strength (K/S), and pH levels of different woven cotton fabrics with varying percentages of other fibers. Here's a breakdown of the information provided:

1- *Wettability*: Fabrics containing lyocell fibers in the weft direction show increased wettability compared to pure cotton fabrics. Specifically, sample 7, which comprises 40% modal and 60% cotton, demonstrates higher wettability than pure cotton fabrics.

2- *Color Strength (K/S)*: Sample 8, consisting of 70% cotton and 30% lyocell, performs better in terms of color strength (K/S 12.95) compared to sample 9 (60% cotton and 40% bamboo with K/S 11.19) and sample 11 (60% cotton and 40% modal fabrics).



	100%cotton	50% Cotton: 50% Flax	60%cotton: 40%modal	70%cotton: 30% lyocell	60%cotton: 40%bamboo	50%cotton: 50%flax	60%cotton: 40%modal	60%cotton: 40%lyocell	70%cotton: 30%bamboo
No.	1	6	7	8	9	10	11	12	13
K/S Color: Blue	9.65	9.81	11.2	12.95	11.19	9.81	11.2	12.95	11.19
PH Level	7.77	7.06	7.49	7.69	7.91	7.06	7.49	7.69	7.91
Wettability	2.26	2.63	2.3	2.4	2.5	2.63	2.3	2.4	2.5

Figure (1) indicate results of the samples with cotton in different percentages.

3- *PH Levels*: There's a significant increase in pH levels noted in sample 9 (60% cotton and 40% bamboo) and sample 13 (70% cotton and 30% bamboo), reaching 7.91.

This data provides insights into how the addition of different percentages of fibers, such as lyocell, bamboo, and modal, can affect the wettability, color strength, and pH levels of cotton fabrics. The results suggest that varying fiber compositions influence these properties, with some combinations leading to improved characteristics compared to pure cotton fabrics.

K/S Values and Color Fastness of Cotton Fabrics

Table 3 presents the K/S values of reactive dyes used in cotton (woven) fabrics, regarding K/S values of reactive dyes used in cotton fabrics suggests several key points:

1. *Inclusion of Lyocell Fiber*: Fabrics that incorporate lyocell fiber show enhanced color fastness, especially in terms of dry-state crocking. This indicates that the presence of lyocell in the fabric composition contributes to better resistance against color transfer during rubbing or friction.
2. *Color Fastness to Laundry*: Effective color fastness to laundry is evident not only in cotton fabrics but also in nylon and polyester fabrics. This implies that these fabrics, including cotton, display good resistance to color fading or bleeding when subjected to washing or laundering processes.

3. Consistently High K/S Values in Woven Fabrics: Woven fabrics, in general, exhibit consistently high K/S values. This indicates that woven cotton fabrics, along with modal and lyocell fabrics, have strong color strength and absorbency for the reactive dyes used.
4. Modal and Lyocell Fabrics: Modal and lyocell fabrics showcase higher K/S values compared to cotton fabrics (woven). This suggests that these fabrics might have better color retention or absorbency for the reactive dyes, resulting in more vibrant or intense colors.

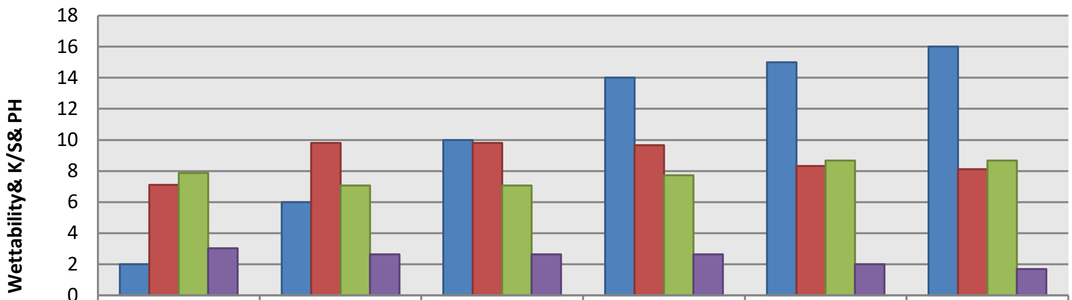
Overall, the table highlights the performance of different fabrics concerning color strength (K/S values) with reactive dyes, emphasizing the positive impact of lyocell fiber and the generally high color strength exhibited by woven fabrics, particularly in modal and lyocell variants compared to woven cotton fabrics.

Wettability, Color Strength (K/S), and pH Level of Flax Fabrics with Different Percentages

Dyeing on woven fabrics comprising varying percentages of flax fiber results in differences in K/S values, wettability, and pH levels. The information provided indicates that dyeing woven fabrics with varying percentages of flax fiber results in differences in K/S values, wettability, and pH levels.

1. K/S Values: Reactive dye applications on woven fabrics with varying percentages of flax fiber result in different K/S values. Reactive dyes demonstrate the highest K/S values, indicating good color strength and absorption.
2. Wettability: While there are slight differences in wettability values among the woven fabrics containing flax fiber, sample 16 (60% flax and 40% lyocell) shows higher wettability (1.7 seconds). Additionally, sample 15 (70% flax and 30% bamboo) exhibits enhanced wettability compared to fabrics made of pure flax. This suggests that incorporating bamboo and lyocell fibers into fabrics containing flax can improve wettability properties.
3. Effects of Incorporating Bamboo and Lyocell: The inclusion of bamboo and lyocell fibers in fabrics comprising flax results in improved properties, particularly in terms of wettability. Sample 15 (70% flax and 30% bamboo) demonstrates enhanced wettability compared to pure flax fabrics, while sample 16 (60% flax and 40% lyocell) exhibits higher wettability values.

In summary, the addition of bamboo and lyocell fibers to fabrics containing flax seems to positively impact properties such as wettability, suggesting potential improvements in fabric characteristics through the incorporation of these alternative fibers in flax-based textiles. Additionally, the use of reactive dyes enhances the color strength (K/S values) of these woven fabrics.



	100%Flax	50% Cotton: 50% Flax	50%cotton:50%flax	70%flax: 30%modal	70%flax:30%bamboo	60%flax:40%lyocell
No.	2	6	10	14	15	16
K/S Color: Blue	7.11	9.81	9.81	9.66	8.32	8.12
PH Level	7.87	7.06	7.06	7.73	8.67	8.67
Wettability	3.03	2.63	2.63	2.64	1.99	1.7

Figure (2) indicate results of the samples with flax in different percentages.

The comparison between different samples utilizing varying percentages of flax fibers reveals interesting observations:

1. Color Strength (K/S) Values: Samples 6 and 10, both containing 50% flax and 50% cotton, demonstrate higher color strength (K/S) values at 9.81 compared to sample number 2, which consists entirely of 100% flax. This suggests that the addition of cotton alongside flax in equal proportions contributes to increased color strength in the resulting fabric.
2. PH Levels: Significant increases in pH levels are noted in sample numbers 15 and 16. Sample 15 contains 70% flax and 30% bamboo, while sample 16 comprises 60% flax and 40% lyocell, reaching a pH level of 8.67. This indicates that the inclusion of bamboo and lyocell fibers in higher percentages within fabrics predominantly made of flax contributes to a notable rise in pH levels.

These findings imply that blending flax with cotton in equal proportions enhances the color strength (K/S values) of the resulting fabric. Moreover, incorporating higher percentages of bamboo and lyocell alongside flax leads to a significant increase in pH levels in the resulting textiles.

K/S Values and Color Fastness of Flax Fabrics

K/S Values of Reactive Dyes in Flax Fabrics (Woven):

- Incorporating lyocell fiber enhances color fastness in flax fabrics, especially in dry-state crocking. This implies that the inclusion of lyocell fiber improves the resistance of the fabric to color transfer or rubbing.
- Effective color fastness to laundry was identified in cotton, nylon, and polyester fabrics, suggesting that these fabrics, including flax, demonstrate good resistance to color fading or bleeding during washing processes.
- Flax fabrics exhibit lower K/S values compared to regenerated fabrics, indicating potentially lesser color strength or absorbency of the reactive dyes in flax fabrics compared to these regenerated fabric types.

Fastness Properties of Reactive Dyes on Different Fabrics (Woven):

- Wash fastness in flax fabrics is notably good compared to other fastness properties like rubbing. This robust wash fastness can be attributed to the strong polymeric reaction between fabric materials and dyes during the dyeing process.
- Rubbing fastness properties in flax fabrics appear to be moderate to poor, potentially due to inherent characteristics of the fabric that affect its resistance to rubbing or friction.
- Overall, the dyed fabrics showcase good overall fastness properties, although rubbing fastness in flax fabrics might be an area of concern.

The importance of various factors in dyeing processes, such as the type of fiber used (e.g., lyocell in enhancing color fastness), as well as the differences in fastness properties like wash and rubbing within the woven flax fabrics and compared to other fabric types. The observations indicate a balance between strengths and weaknesses in the dyeing and fastness properties of flax fabrics, particularly concerning color fastness and durability against rubbing.

Wettability, color strength (k/s) and PH level of modal fabrics with different percentage.

The provided information sheds light on variations in K/S values, wettability, and pH levels among different fabric compositions, particularly regarding the behavior of woven fabrics treated with reactive dye.

1- K/S Values and Fabric Compositions:

- Reactive dye application demonstrates maximum K/S values, indicating strong color strength and dye absorption in the fabrics.
- Variations in K/S values are noted among different fabric compositions, with reactive dye showcasing the highest values.

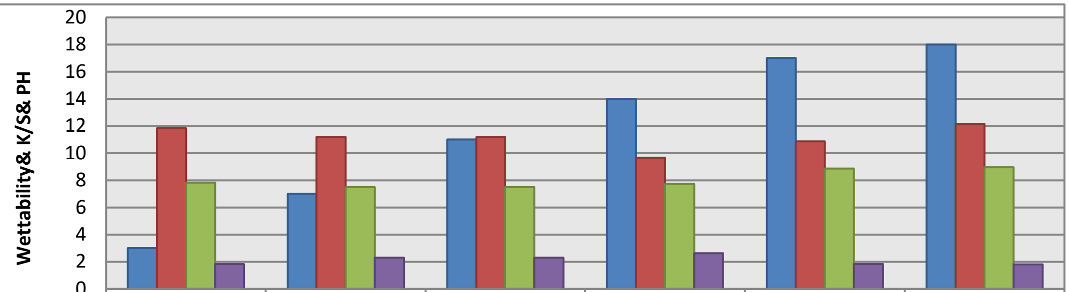
2- Wettability:

- Minor differences in wettability are observed among the woven fabrics.
- Sample 3 (100% modal) and sample 17 (50% modal and 50% bamboo) display comparable wettability at 1.83 seconds.
- However, sample 14 (70% flax and 30% modal) exhibits lower wettability compared to pure modal fabrics in woven samples.

3- Modal Fiber Characteristics and Wettability:

- The observation suggests that the cross-section of modal fibers is smoother compared to viscose, resulting in a higher molecular weight and a smoother surface.
- These characteristics contribute to a higher wet modulus and enable greater molecular orientation during fiber stretch and coagulation, potentially leading to enhanced wettability.
- The differences in fabric compositions concerning their K/S values, wettability, and suggests that the unique characteristics of modal fibers, particularly their smoother surface and higher molecular weight, contribute to their wettability properties in woven fabrics.

This information aids in understanding how different fiber compositions impact the physical properties of the resulting textiles, particularly in terms of wettability.



	100% Modal	60%cotton: 40%modal	60%cotton: 40%modal	70%flax: 30%modal	50%modal:50bamboo	50%modal:50%lyocell
No.	3	7	11	14	17	18
K/S Color: Blue	11.84	11.2	11.2	9.66	10.86	12.17
PH Level	7.83	7.49	7.49	7.73	8.87	8.96
Wettability	1.83	2.3	2.3	2.64	1.83	1.8

Figure (3) indicate results of the samples with modal in different percentage.

K/S Values and Color Fastness of Modal Fabrics

The K/S values of reactive dyes in cotton (woven) fabrics are detailed in Table 3, K/S values and color fastness of modal fabrics compared to cotton (woven) fabrics suggests several key points:

1. Superior Color Fastness of Modal Fiber:
    - The utilization of modal fiber results in superior color fastness, especially in dry-state crocking. This implies that modal fabrics show better resistance to color transfer or rubbing during frictional contact.
    - Effective color fastness in laundry was observed not only in modal fabrics but also in cotton, nylon, and polyester fabrics. This indicates good resistance to color fading or bleeding during washing processes across various fabric types.

2. High K/S Values in Woven Fabrics, Particularly Modal:
    - Woven fabrics, in general, exhibit high K/S values, which indicates strong color strength and dye absorbency.
    - Modal fabric demonstrates higher K/S values compared to cotton fabrics (woven). This could be attributed to specific characteristics of modal fibers.

3. Attributes of Modal Fibers Contributing to Color Fastness:
    - Modal fibers typically possess a circular cross-section, a long, straight fiber structure, and contain a 25-35% crystalline region within the fiber.
    - The degree of polymerization of glucose units in cellulose chains for Modal fibers ranges from 200-700, indicating the length and arrangement of polymer chains, which might contribute to the superior color fastness observed in modal fabrics.
    - The inherent characteristics of modal fibers, such as their cross-section, crystalline regions, fiber structure, and degree of polymerization, contribute to the superior color fastness observed in modal fabrics compared to cotton fabrics. These characteristics play a significant role in determining the dye absorbency, color strength, and resistance to color fading or transfer in the dyed fabrics.

Wettability, Color Strength (k/s) and PH level of bamboo fabrics with different percentage.

the results of an experiment involving bamboo fabrics with varying percentages in combination with other materials like cotton, focusing on properties such as wettability, color strength (K/S values), and pH levels. Here's a breakdown of the findings wettability, color strength (K/S values), and pH levels. Here's a breakdown of the findings:

1. Wettability:
    - Sample 4 (100% bamboo) showed a wettability of 1.59 seconds.
    - Sample 9 (60% cotton, 40% bamboo) showed a wettability of 2.5 seconds.
    - Sample 13 (70% cotton, 30% bamboo) exhibited lower wettability than pure bamboo fabrics.
2. Color Strength (K/S Values):
    - Reactive dye resulted in the maximum K/S values, specifically in bamboo fabrics.
3. Cellulose Structure in Bamboo:
    - The structure of the cellulose molecule in bamboo comprises three planes that are perpendicular to each other.
    - These planes are held together differently: by numerous hydrogen bonds in the first plane, weaker Van der Waals forces in the second plane, and covalent bonds in the third plane.

<u>Based on the findings presented:</u>

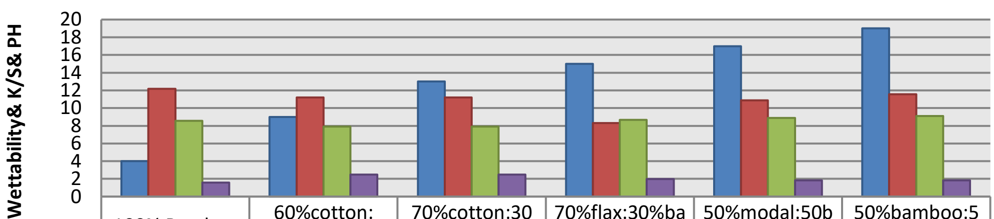
- Woven bamboo fabrics showed differences in wettability.
- Reactive dye appeared to have a significant impact on enhancing color strength (K/S values) in bamboo fabrics.
- The discussion about the cellulose structure in bamboo likely provides context for the observed differences in properties like wettability, implying that the bonding in different planes affects fabric properties differently.

The relationship between the composition of the fabrics, the dye used, and the resultant properties like wettability and color strength seems to be a significant aspect of this study, highlighting the importance of material composition and treatment methods in determining fabric characteristics.

K/S values and color fastness of bamboo Fabrics

From the information provided, it seems that the K/S values (color strength) and color fastness of bamboo fabrics dyed with reactive dyes in comparison to other fibers like cotton, modal, nylon, and polyester:

4. <u>K/S Values:</u>
    - The K/S values of reactive dyes in cotton (woven) fabrics are given in Table 2, but specific values or comparisons with bamboo fabrics.
    - It's implied that modal fiber results in better color fastness to crocking (rubbing) than cotton.
    - There's a suggestion that bamboo fibers exhibit good dye ability, likely indicated by higher K/S values in comparison to other fibers.



	100% Bamboo	60%cotton: 40%bamboo	70%cotton:30 %bamboo	70%flax:30%ba mboo	50%modal:50b amboo	50%bamboo:5 0% lyocell
No.	4	9	13	15	17	19
K/S Color: Blue	12.17	11.19	11.19	8.32	10.86	11.57
PH Level	8.56	7.91	7.91	8.67	8.87	9.1
Wettability	1.59	2.5	2.5	1.99	1.83	1.83

Figure (4) indicate results of the samples with bamboo in different percentages.

5. K/S Values:
    - The K/S values of reactive dyes in cotton (woven) fabrics are given in Table 2, but specific values or comparisons with bamboo fabrics.
    - It's implied that modal fiber results in better color fastness to crocking (rubbing) than cotton.
    - There's a suggestion that bamboo fibers exhibit good dye ability, likely indicated by higher K/S values in comparison to other fibers.
6. Color Fastness:
    - Bamboo fibers are noted for their ability to absorb moisture due to their structure, which includes small gaps and voids.
    - This moisture absorption capability allows bamboo to wick moisture through micro channels, contributing to comfort when worn.
    - The presence of these gaps and voids in bamboo's structure likely contributes to its better dye ability, leading to enhanced color fastness.
7. Attributes of Bamboo Fiber:
    - Bamboo fibers are characterized by:
        - High moisture absorption capacity, contributing to comfort.
        - Good dye ability due to the small gaps and voids in their structure.
        - Soft hand feels and a pleasant luster, possibly due to their inherent properties.

The advantages of using bamboo fibers in fabric production, emphasizing their ability to absorb moisture, good dye ability resulting in higher K/S values, and attributes such as comfort, softness, and a pleasant luster. This makes bamboo a favorable choice for fabric production, especially when considering color fastness and comfort in wearing apparel.

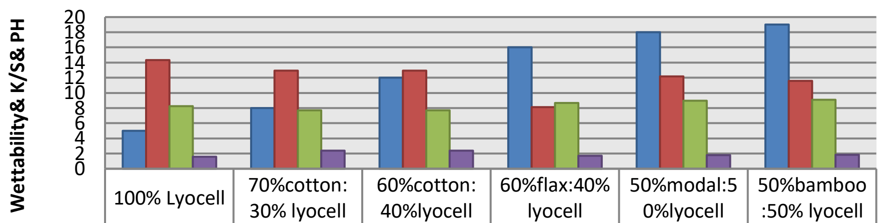
Wettability, color strength (k/s) and PH level of lyocell fabrics with different percentage

From the information provided, it appears that an experiment was conducted involving lyocell fabrics with varying percentages and their properties regarding wettability, color strength (K/S values), and pH levels. Here's a breakdown of the findings:

1. <u>Wettability:</u>
    - Sample 5, consisting of 100% lyocell, exhibited a wettability of 1.6 seconds.
    - Sample 16, composed of 60% flax and 40% lyocell, had a wettability of 1.7 seconds.
    - Sample 8, containing 70% cotton and 30% lyocell, showed lower wettability compared to other fabrics in the woven fabrics.
2. <u>Tencel Fiber Structure Comparison:</u>
    - The results suggest that Tencel (a brand of lyocell) fibers have a complex structure consisting of micro- and macro-fibrils.
    - Tencel fibers exhibit a higher degree of crystallinity and molecular orientation compared to bamboo fibers, likely impacting their properties such as wettability and strength.

<u>Based on the observations:</u>

- Different compositions of lyocell fabrics showed slight variations in wettability.
- The comparison of Tencel (lyocell) fiber structure to bamboo suggests differences in crystallinity and molecular orientation, which could account for differences in fabric properties.
- It seems that differences in fabric properties based on lyocell fabric compositions and compares the structure of Tencel fibers to bamboo, emphasizing the structural complexity and characteristics of lyocell fibers that contribute to their unique properties like wettability and strength. However, specific data regarding color strength and pH levels in relation to the different lyocell fabric compositions is not provided.



	100% Lyocell	70%cotton: 30% lyocell	60%cotton: 40%lyocell	60%flax:40% lyocell	50%modal:50%lyocell	50%bamboo :50% lyocell
No.	5	8	12	16	18	19
K/S Color: Blue	14.34	12.95	12.95	8.12	12.17	11.57
PH Level	8.26	7.69	7.69	8.67	8.96	9.1
Wettability	1.6	2.4	2.4	1.7	1.8	1.83

Figure (5) indicate results of the samples with lyocell in different percentages.

K/S values and color fastness of lyocell Fabrics

The K/S values (color strength) and color fastness of lyocell fabrics dyed with reactive dyes, particularly in comparison to cotton (woven) fabrics:

1. K/S Values and Color Fastness:
    - Reactive dyes applied to cotton (woven) fabrics are documented in Table 2.
    - Lyocell fiber results in better color fastness to crocking, especially in dry conditions.
    - Effective color fastness to laundry is noted in cotton, nylon, and polyester.
2. Morphological Structure of Lyocell Fiber:

   Lyocell (Tencel) fibers exhibit specific morphological characteristics:
    - Thin, nano-porous skin approximately 150 nm thick with low porosity at the fiber's center.
    - A dense cellulosic network structure with finely distributed voids.
    - Uniform cross-section, except for a small boundary layer with higher density.
    - Round, smooth, and consistent cross-sectional shape facilitates close packing in yarn structures.
    - The unique morphology of lyocell fibers, particularly Tencel, contributes to their advantageous properties in dyeing and color fastness. The nano-porous skin, dense network structure, and uniform cross-section likely play significant roles in enhancing color fastness, allowing for effective dye absorption, and contributing to the overall quality and performance of lyocell fabrics. However, specific K/S values or detailed comparisons regarding color strength between reactive dyes on cotton fabrics and lyocell fabrics are not provided. The focus here seems to be on the structural attributes of lyocell fibers that contribute to their favorable dyeing properties and Color fastness.

Conclusion

From the provided information, several conclusions can be drawn regarding the properties of lyocell fabric in comparison with cotton, flax, modal, and bamboo fabrics:

1. Wettability:
   - Lyocell fabric exhibits excellent wettability both in the weft direction and overall, surpassing cotton and flax fabrics.
   - Fabrics made from modal, bamboo, and lyocell show higher pH level coefficients compared to cotton and flax fabrics.
   - Among natural fabrics, modal, bamboo, and lyocell fabrics display higher wettability values than cotton and flax.

2. Color Strength (K/S Values):
   - The K/S values of dyes applied to fabrics made from cotton, flax, modal, bamboo, and lyocell are good.
   - Reactive dyes exhibit good K/S values, similar to the trend observed in cotton fabrics.

3. Fastness Properties:
   - Reactive dye woven modal fabrics display comparatively good fastness properties (wash and rubbing) compared to cotton fabrics.
   - Regenerated fabrics, such as modal, bamboo, and lyocell, generally exhibit better overall fastness properties compared to natural fabrics.

4. Dyeing Effect:
   - Modal, bamboo, and lyocell fabrics demonstrate good dyeing effects, outperforming cotton and flax fabrics.
   - The superiority of lyocell fabric in terms of wettability and color strength (K/S values) compared to cotton, flax, modal, and bamboo fabrics. Additionally, the fastness properties, especially in regenerated fabrics like modal, bamboo, and lyocell, are generally better than those observed in natural fabrics. Overall, modal, bamboo, and lyocell fabrics showcase improved dyeing effects and fastness properties, positioning them favorably against traditional natural fabrics like cotton and flax.

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تعزيز خصائص ثبات اللون في أقمشة التنجيد: تحليل شامل للخصائص المتعددة الوظائف في الأقمشة المنسوجة بنسب متنوعة من الألياف

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المستخلص:
تتناول هذه الدراسة الخصائص المتعددة الوظائف للأقمشة المنسوجة المكونة من نسب متنوعة من الخلطات من ألياف القطن والكتان والمودال والبامبو واللايوسيل (التنسيل)، مع التركيز الخاص على تأثيرها على أقمشة التنجيد. تقوم البحث بتقييم مستويات K/S لثبات اللون، وثبات اللون أثناء الغسيل، وثبات اللون أثناء التحميل، ومستويات الحموضة لهذه الأقمشة المنسوجة المصنوعة من تركيبات مختلفة من الخيوط في اتجاه اللحمات. تم استخدام أساليب الاختبار الموحدة، وتم تحليل النتائج إحصائياً ومقارنتها عبر تركيبات أقمشة متنوعة، وتشير النتائج إلى أن إضافة خيوط اللايوسيل تعزز بشكل ملحوظ خصائص ثبات اللون لأقمشة التنجيد. ويُلاحظ أن فعالية ثبات اللون للأقمشة تتأثر بنسب محتوى الألياف في خيوط اللحمة وخصائص النسيج المحددة. وبالإضافة إلى ذلك، يرتبط هذه التأثيرات بشكل وثيق بالخصائص الهيكلية لليوسيل، بما في ذلك تركيبه وخصائصه في المقطع العرضي.

الكلمات مفتاحية: المودال؛ البامبو؛ اللايوسيل: ثبات اللون