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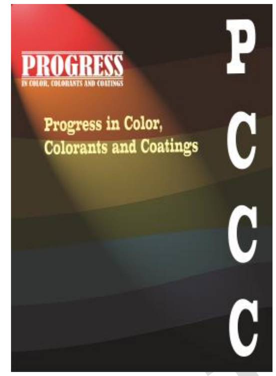

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Statistical Analysis of Levelness Parameter of CTAC Modified Cotton Knit Dyed with Fluorescent Pigment in Pad Batch Method

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Abstract

Dispersion stability and application method of fluorescent pigment have a great influence on the level dyeing of cotton fabric. Focusing on this, cotton knit fabric is cationized with Cetyl Trimethyl Ammonium Chloride (CTAC), and then dyed with fluorescent pigment in the pad batch method. Here, cationization was performed so that fluorescent pigment can be entrapped on it, which reduces their migration, thus providing dispersion stability to provide level dyeing. The effect of varying pretreatment conditions was investigated, and optimum conditions for cationization and pigmentation were established in terms of statistical parameters of K/S value, like standard deviation (S), relative standard deviation (S_r), levelness (L), and unlevelness (U) parameters to obtain an accurate numerical value of levelness of cellulose fabric dyed with fluorescent pigment. The results display at p^H 9 and 54g/l CTAC concentration, providing higher CTAC adsorption. Besides, FTIR spectrophotometry analysis of scoured, bleached, and CTAC adsorbed fabric is carried out to reveal adsorption chemistry. Furthermore, for characterization of samples, color fastness to water, wash, perspiration (acidic and alkaline), and rubbing (wet and dry) are performed. Although tensile strength has increased, a slight reduction in bursting strength and softness of the dyed fabric is observed. However, the main novelty of this research is the utilization of the cationizer named CTAC that is padded before fluorescent pigment applications. The outcomes of the statistical analysis of the levelness parameter also suggest that the greater efficacy of CTAC for level dyeing of fluorescent pigmented fabric can be used in fashion as well as functional purposes.

Keywords: Fluorescent pigment, Cat-ionizer, data analysis, uniform dyeing.

1. Introduction

Fluorescent pigment with high reflectivity and bright color is one of the important categories of pigment that has foresight a sustained growth over the past few decades because of its special properties like extremely high visibility and its ability to attract the attention of consumers for a second look, which makes it different from conventional color [1, 2]. Actually, the composition of daylight fluorescent pigment involves the fluorescent dye dissolved in a colorless, transparent solid polymer of a fine particle size [3-5]. Among a variety of special applications, they serve in textile printing and dyeing for aesthetic fashion, also for functional reasons such as sportswear, work wear, leisure wear, traffic police’s clothing, children’s clothing, travel clothing, and so on to enhance visibility [6, 7]. But the low affinity of fluorescent pigment and textile substrate and poor dispersion ability of fluorescent pigment lead to uneven dyeing, which restricts the applications of fluorescent pigment [8, 9]. A lot of effort has been made to solve the problem. Pigment dyeing of cotton knit fabric in the exhaust and pad dry method is very common [10]. For instance, by modification of cotton knits with cationizer, the affinity between them can be increased because a positive charge is introduced into the fabric surface by cationic pretreatment of fabric and thus it is attracted by negatively charged pigment [11]. In the exhaust method, due to the absence of substantivity of pigment dispersion towards cotton, cationization is done, which is then exhaust dyed with pigment dispersion [12-15]. But still, unevenness is a major problem in the exhaust dyeing method [16]. Besides, Fluorescent pigment latex encapsulated in poly (methyl-co-butyl acrylate) was prepared to improve the stability of fluorescent pigment during dyeing with CHPTAC (3-chloro-2-hydroxypropyltrimethyl ammonium chloride) modified cotton knits in the exhaust method. Though better levelness is obtained here, the preparation of fluorescent latex makes the process difficult [7]. Moreover, in the conventional pad-dry technique, because of repulsion between the pigment dispersion and the cellulose surface, level dyeing and obtaining a dark shade become difficult. The aforementioned problems can be overcome by padding the cellulose with cationic dispersant, pigment, and film-forming polymer, followed by drying and curing [17].

In the present work, cotton knit fabric was modified with a cationic surfactant named Cetyl Trimethyl Ammonium Chloride (CTAC), and dyed with fluorescent pigment in a pad batch method to minimize uneven dyeing. Here, modification of cotton knits is carried out by a cationic surfactant to introduce stable positive electrostatic charges on the surface to attain better dispersion stability of the fluorescent pigment. This is possible as the cellulose surface is negatively charged in neutral and alkaline media. Statistical analysis of process parameters like concentration of cationic surfactant, pH, temperature, time, and binder concentration on levelness parameters such as standard deviation of K/S ($\sum S(\lambda)$, relative standard deviation of K/S ($\sum Sr(\lambda$), color levelness (L), and unlevelness (U) for cationization and pigmentation facilitates determining the applicability of fluorescent pigment for industrial usage. Scanning Electron Microscopy (SEM) analysis of scoured, bleached, and CTAC adsorbed cellulose was also carried out. Moreover, the chemistry of CTAC adsorbed cellulose was investigated by Fourier-transform infrared spectroscopy (FTIR) and finally, fluorescent pigmented cotton knit samples were characterized by color fastness properties.

2. Experimental

2.1 Materials and chemicals

Scoured and bleached cotton single jersey knit fabric with 160 g/m^2 was supplied by Micro Fiber Group, Bangladesh. For Neon Red E-12 was supplied by Orient Chem Ltd., Bangladesh. Other chemicals and auxiliaries such as cationic surfactant Forcat BCD (Cetyl tri-Methyl Ammonium Chloride), binder Forbind OB-45 (acrylic resin binder) and anti-foaming agent Forfoam NS were provided by Orient Chem Ltd., Bangladesh.

2.2 Methods

2.2.1 Cationization and dyeing in the pad batch method

Samples were padded (75% pick up) with Forcat BCD in a laboratory padder for cationization, where process variables pH of cationization bath and concentration of cationizer, were varied from 4 to 10 and 0 to 94g/L, respectively. Then pigmentation was done with For Neon Red E-12 with pH 4 to 10 and batched for variable time, 3 to 18 hours, with intervals of 3 hours. After batching, samples were padded again with Forbind OB-45 of different concentrations from 1 to 6% continued drying at 100℃ for 1 minute, and finally curing at 150℃ for 1.5 minutes.

2.2.2 Estimation of color strength

Color yield (K/S) values of the dyed samples were calculated by using a data color 650 spectrophotometer under D_{65} illumination, 10˚ viewing geometry in the measurement range from 400nm to 700nm, in which 530nm gave the maximum wavelength to measure the color strength of the samples. K/S values were calculated from the Kubelka-Munk equation (Eq. 1):

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \qquad (1)$$

Where K and S are the absorption and scattering coefficients, and R is the reflectance at the maximum wavelength.

2.2.3 Statistical analysis of samples:

Statistical analysis of differently dyed fabrics is determined by a random sampling method. Color levelness parameter can be calculated by measuring K/S values with the help of a spectrophotometer on 10 random sample spots between the wavelengths of 400-700nm with an interval of 20nm.

The following statistical data is used to find out levelness parameter.

i) Standard deviation of K/S ($\sum S(\lambda)$),

ii) Relative standard deviation of K/S ($\sum Sr(\lambda$)),

iii) Color levelness (L) parameter (Eq. 2),

iv) Unlevelness (U) parameter

Estimation of the levelness parameter

i) Standard deviation:

$$S(\lambda) = \sqrt{\frac{\sum_{i=1}^{n}\left[(K/S)_{i,}\lambda - (\overline{K/S)\lambda}\right]^2}{n-1}} \qquad (2)$$

where, λ =Wavelength of the estimation, n = total number of estimations.

$(K/S)_{i,}$ λ = K/S value of the i th estimation at λ and

$$\overline{(K/S)\lambda} = \frac{1}{n}\sum_{i=1}^{n}(K/S)_{i,}\lambda \qquad (3)$$

Standard deviation determines the deviations of K/S at different places of the same fabric. To compare the L of two pieces of fabric with different K/S, a relative value of the sample standard deviation $S_r(\lambda)$ is required.

ii) Relative standard deviation (Eq. 4):

$$S_r(\lambda) = \sqrt{\frac{\sum_{i=1}^{n}\left[\frac{(K/S)_{i,}\lambda}{\overline{(K/S)\lambda}} - 1\right]^2}{n-1}} \qquad (4)$$

As human sensitivity differs from that of the instrument at different wavelengths, $S_r(\lambda)$ is adjusted by the spectral luminous function $[V(\lambda)]$. It is related to visual observation and the unlevelness parameter can be calculated from the following equation:

iii) Unlevelness parameter (Eq. 5):

$$U = \sum_{\lambda=400}^{700} S_r(\lambda)V(\lambda) \qquad (5)$$

A larger U means levelness is poor. V(λ) is the luminous efficiency function.

Though the levelness of the textiles can be measured by using the U value, its value is not as sensitive to the material with high and low color levelness. This problem can be overcome by the L parameter which gives better proportional agreement with actual levelness increments.

iv) Levelness parameter (Eq. 6):

$$L = 1.20\left[2.00 - \ln \sum_{\lambda=400}^{700} S_r(\lambda)V(\lambda)\right] \tag{6}$$

Where 1.2 and 2.00 remain constant to adjust the value. Here, larger L values indicate better levelness of the colored sample [18-20].

2.2.4. Characterization

2.2.4.1. Structural analysis by Fourier Transform Infrared Spectroscopy (FTIR-ATR)

Bonding between cationic surfactant and cotton cellulose was determined by FTIR from the Centre for Advanced Research in Science (CARS) of Dhaka University (DU).

2.2.4.2 Analysis of color performance

Color fastness was evaluated according to the international standards. Color fastness to water: ISO 105 E01, color fastness to wash: ISO 105-C06 (C2S), color fastness to perspiration: ISO 105 E04, color fastness to rubbing (dry and wet): ISO 105-X12, color fastness to light: ISO 105-B02:2014 were assessed to measure the color performance of dyed samples.

2.2.4.3 Evaluation of mechanical properties

The test method ASTM D5034 was employed to estimate tensile strength and elongation at break, both in wales and course direction of dyed knit fabric, utilizing the Titan Universal Strength tester of James Heal, USA. Bursting strength of the dyed knit fabric was tested according to ASTM D3786 using a bursting strength tester of James Heal, USA. The test method ASTM D1388 was carried out to measure the stiffness of fabric using by Shirley stiffness tester. The control and dyed fabrics are conditioned in a conditioning chamber under standard atmosphere (at 20 ± 5 °Cand 65± 2% relative humidity for 12 h) before every test.

3. Results and Discussion

3.1. Structural analysis by Fourier Transform Infrared Spectroscopy (FTIR-ATR)

Figure 1 illustrates the ATR-FTIR spectra of scoured and bleached cotton fabric and cationic surfactant-treated cotton fabric. The characteristic cellulose peak at around 1200-800 cm^{-1} was shown by the spectra of scoured and bleached cotton fabric [21], such as 1115, 1160, and 1028 cm^{-1} are mainly observed, among which the bond at 1115 cm^{-1} corresponds to C-OH skeletal vibration, the band at 1160 cm^{-1} is associated with C-O-C ether linkage of skeletal vibration, and 1028 cm^{-1} ascribes primary C-O-H stretching respectively. Besides, 1430 cm^{-1}meets the banding of C-O-H alcohol groups in plane. A strong absorption band at 3340 cm^{-1} accounts for the intermolecular hydrogen-bonded O-H stretching of cotton cellulose. Besides, 3410 and 3305 cm^{-1} bands indicate the dominant conformation of primary alcohols and minor conformation of secondary alcohol, respectively [22].

Again, analysis of CTAC treated cellulose shows three notable absorption bands, at 1214 cm^{-1} is the characteristic of C-N stretching of amine [23], stretching at 1375 $cm^{-1}$is associated with C-H stretching of $–CH_3$ group [22] and stretching at about 2945 and 2850 $cm^{-1}$are associated with asymmetric and symmetric stretching of C-H bonds which are characteristic of $-CH_2-$ groups present in the aliphatic chain of CTAC which ensured the presence of quaternary $N^+(CH_3)_4$ functional group. These observations show clearly the incorporation of a cationic N^+R_4 group into the cellulose surface. Moreover, due to the presence of adsorbed surfactant on cellulose, the intensities of the perturbed hydroxyl bands shift downward from 3410 to 3468 $cm^{-1,}$ which exposed the importance of hydroxyl groups in the sorption of cellulose [24].

The CTAC surfactant molecules aggregate as a monolayer, forming hydrophobic cores composed of surfactant tails that can trap organic compounds, such as fluorescent pigments. This provides dispersion stability for the fluorescent pigment, facilitating the level dyeing of dyed fabrics. This phenomenon is demonstrated in Figure 2.

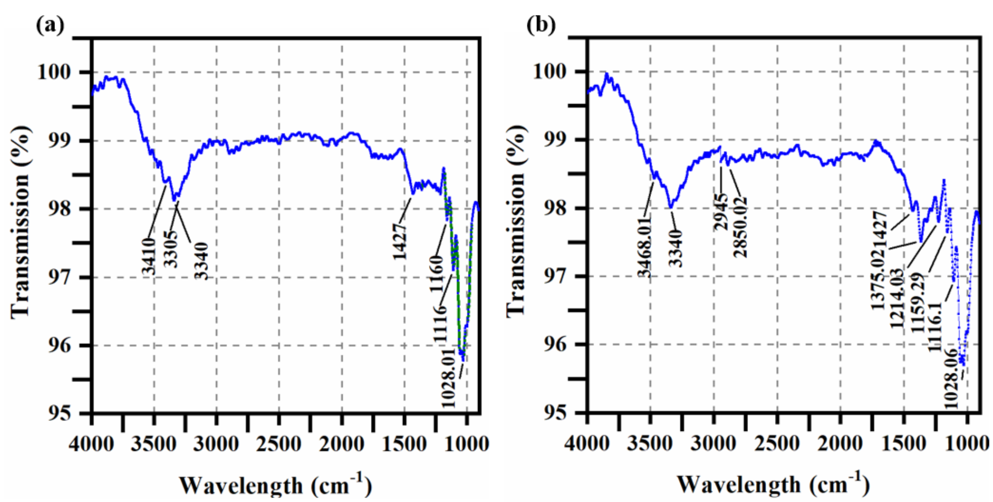

Figure 1: ATR Infrared spectra of (a) scoured and bleached cotton and (b) CTAC adsorbed cotton.

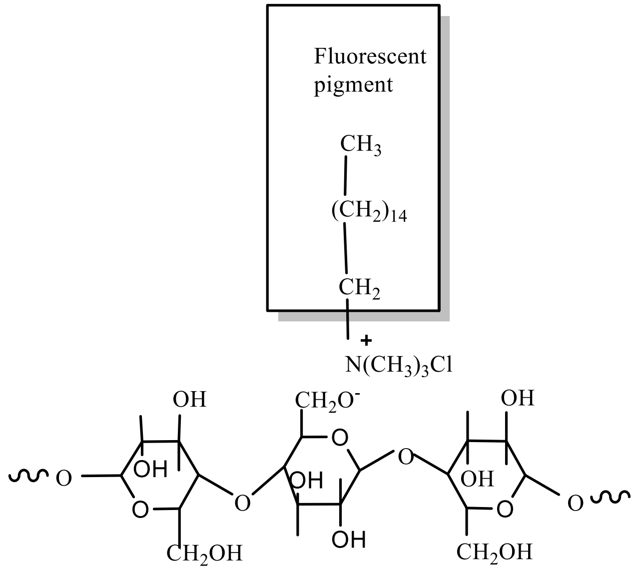

Figure 2: Possible schematic representation of CTAC adsorbed cellulose dyed with fluorescent pigment.

3.2. Statistical analysis for cationization in the cationic pad batch method

In the pad batch method, the effect of P^H and the effect of CTAC concentration are observed in terms of K/S for cationization. Statistical data like the standard deviation of K/S ($\sum S(\lambda)$), relative standard deviation ($\sum S_r$), color levelness (L), and unlevelness (U) parameter were determined by using equations 2, 4, 5, and 6. Further analysis of these values helped to find a suitable pH and CTAC concentration, which enabled us to find out the most levelled sample in this method.

3.2.1 Effect of pH

Table 1 depicts the statistical values of K/S with SD, $\sum S, \sum S_r$, L and U at different P^H for cationization in the pad batch method. In the cationic pad batch method, the influences of pretreatment pH on the fluorescent pigment dyeing were investigated in Figure 3 a, b shows the effect of pH on color yield with standard deviation.

Here, electrostatic attraction is the driving force for CTAC adsorption on the cotton surface [25]. Actually, alkaline medium facilitates the dissociation of some of the hydroxyl groups in the cellulose and increases the negative surface charge by forming the cellulosate ion [26]. It can be seen that the K/S value will reach a maximum at pH 9 which indicates a higher negative polarity of cellulose reached at that pH. As a result, most adsorption of CTAC occurred by electrostatic attraction. Too high and too low P^H hinders the adsorption of CTAC with cellulose. So, the K/S value was decreased. By investigating the value of standard deviation, it was also found that the lowest standard deviation was obtained at pH 9 which was also supported by the unlevelness value U and levelness value L.

Table 1: K/S with Standard deviation, $\sum S, \sum S_r$, L and U at different P^H.

pH	K/S	Standard deviation of K/S	$\sum S$	$\sum S_r$	Unlevelness (U)	Levelness (L)
4	2.67	0.15	0.34	1.48	0.36	3.61
5	2.7	0.15	0.62	1.25	0.32	3.76
6	2.8	0.14	0.35	1.42	0.33	3.72
7	2.95	0.12	0.61	1.06	0.31	3.8
8	3.08	0.1	0.67	1.05	0.26	4.03
9	3.28	0.093	0.41	1.24	0.22	4.19
10	3.06	0.14	0.55	1.02	0.25	4.04

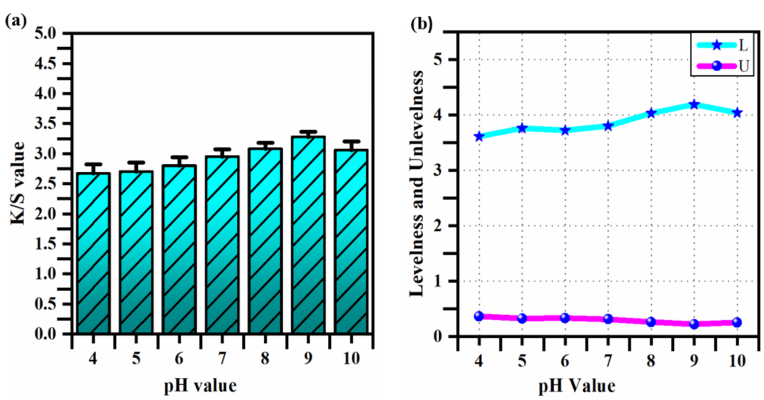

Figure 3: (a) K/S with SD at different and (b) 6   L and U at different pH for cationization in pad batch method.

3.2.2. Effect of CTAC concentration

Dyeing with pigment creates significant unlevelness and the levelness is improved by quaternary cationic surfactant CTAC, which can improve the disperse stability of pigment [27]. It should be noted that the adsorption of cationic surfactant increased with increasing surfactant concentration to a maximum near the critical micelle concentration, then decreased with further increase in surfactant concentration. This is because concentration below CMC leads to a 5hdecrease in surface tension that enhances the wicking of the CTAC into the cotton fiber pores. On the other hand, above the CMC the adsorption decreased with further increase of CTAC concentration because of micelle formation as large amount of CTAC partitioned into the micelles and thus reducing the adsorption on the fiber surface [24].

K/S with SD, $\sum S, \sum S_r$, L and U at different concentrations of Forcat BCD for cationization in the pad batch method is demonstrated in Table 2. Figure 4 a, b shows the effect of CTAC concentration on color yield with standard deviation, levelness and unlevelness parameter at concentrations ranging from 0 to 94 g/L. It is apparent from the figure that the K/S value is only 1.22 on untreated cellulose fiber, but increased to 3.1 at 54 g/L CTAC which indicates the improvement of uptake of pigment due to the addition of CTAC. Above 54g/L concentration value decreases, presumably due to overcoming the CMC of CTAC which leads to form a micelle, which hinders the adsorption of CTAC on cellulose. Obtained result of color uniformity from standard deviation, levelness and unlevelness value, also suggested that a better color levelness value, 4.24, is also obtained at 54g/L CTAC concentration.

Table 2: K/S with Standard Deviation, $\sum S, \sum S_r$, L and U at different concentration of Forcat BCD.

Conc. of Forcat BCD (g/l)	K/S	Standard deviation of K/S	$\sum S$	$\sum S_r$	Unlevelness (U)	Levelness (L)
0	1.22	0.15	0.58	2.26	0.71	2.79
14	2.11	0.19	0.73	1.59	0.51	3.21
40	2.97	0.17	0.61	1.2	0.42	3.43
54	3.1	0.09	0.39	0.64	0.21	4.24
67	3	0.1	0.52	1.39	0.27	3.9
80	2.92	0.15	0.39	0.91	0.28	3.94
94	2.81	0.17	0.18	0.89	0.34	3.74

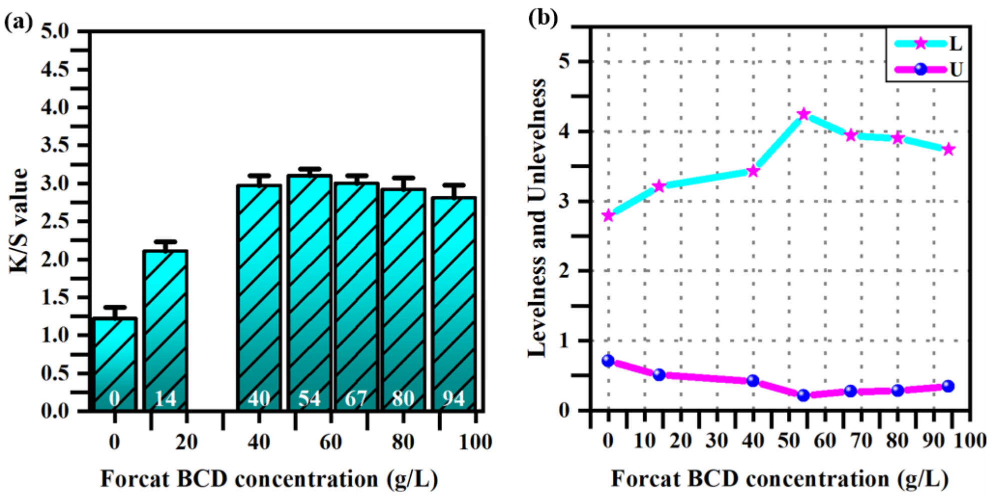

Figure 4: (a) K/S with SD and (b) L and U at different CTAC concentration for caionization in pad batch method.

3.3. Statistical analysis for pigmentation in the cationic pad batch method

In the cationic pad batch method, the effect of pH, binder concentration and batching time is observed in terms of K/S for pigmentation. Statistical data like the standard deviation of K/S ($\sum S(\lambda)$), relative standard deviation ($\sum S_r$ **)**, color levelness (L), and unlevelness (U) parameter were determined by using equations 2, 4, 5, and 6. Further analysis of these values helped to find the suitable pH, binder concentration and batching time which facilitates to find out the most levelled sample in this method.

3.3.1 Effect of pH

Table 3 shows the statistical values of K/S with SD, $\sum S, \sum S_r$, L and U at different pH for pigmentation in the pad batch method. Figure 5 a, b illustrates the effect of pH on color yield and indicates that the K/S value of dyed fabrics increased as the bath pH increased from 4 to 7 and further increasing the pH decreased K/S. This is attributed to the reason that when pH is lower than 7, the positive charges in the dye bath will neutralize the surface charge of pigment particle [7] and pH higher than 7 may create repulsive force both may hinder the absorption of fluorescent pigment on the hydrophobic chain of CTAC [27] And supporting this, highest levelness value 4.2 also found at pH 7 and unlevelness value 0.21 which was the lowest among all values. Hind Algamdy observed uptake of fluorescent pigment reached its highest at pH 8 [3] and Li et al. also found the value is p^H 7 which is very inconvenient in this context [17]. So, it can be said that in neutral to alkaline medium during dyeing uptake of fluorescent pigment reached its peak.

Table 3: K/S with Standard deviation, $\sum S, \sum S_r$, L and U at different P^H.

P^H	K/S	Standard deviation of K/S	$\sum S$	$\sum S_r$	Unlevelness (U)	Levelness (L)
4	2.8	0.15	0.78	0.97	0.38	3.55
5	2.88	0.14	0.59	1.03	0.33	3.71
6	3.1	0.1	0.63	1.28	0.26	4
7	3.3	0.09	0.46	0.66	0.21	4.2
8	3.09	0.11	0.39	0.8	0.24	4.06
9	3	0.12	0.55	1.03	0.25	4.03
10	2.95	0.15	0.51	1.1.9	0.28	3.92

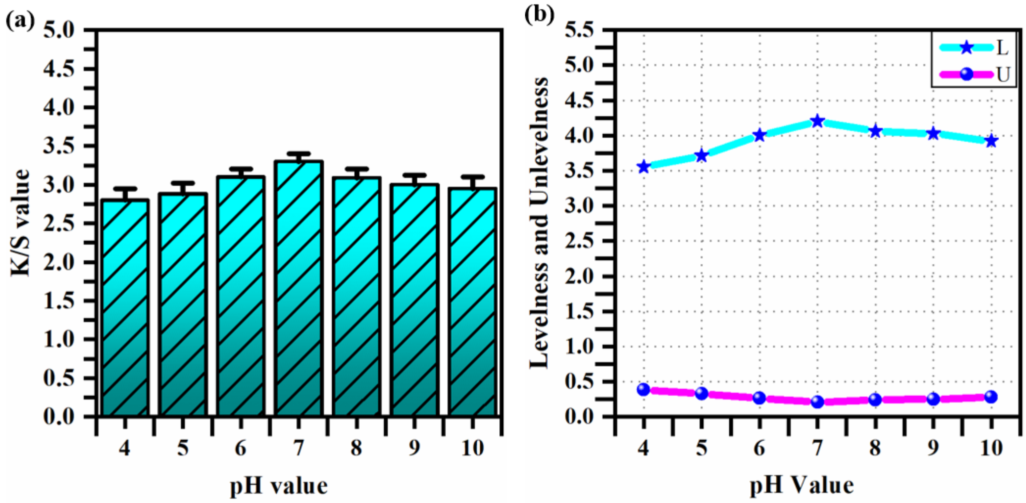

Figure 5: (a) K/S with SD and (b) L and U parameter at different p^H^ for pigmentation in pad batch method.

3.3.2 Effect of batching time

Table 4 depicts the K/S with SD, $\sum S$, $\sum S_r$, L, and U at different batching times for pigmentation in the pad batch method. The pad batch dyeing process is carried out at room temperature with different lengths of batching times to ensure an economic operation. Figure 6 a demonstrates that low color strength required a period of 3 hours, medium color strength of 6-12 hours and high color strength period of 15-18 hours. The color strength is increased as the batching time increases for cellulose fiber and becomes steady after 15 hours of batching time. The results of the standard deviation indicate that at 15 hours of batching time lowest value is obtained, which indicates better color uniformity. Though at 18 hours, color strength remains similar but color uniformity decreased. By investigating Figure 6 b, it is also found that the Levelness L value increases up to 15 hours of bathing time, then decreases and the U value follows the reverse trend.

Table 4: K/S with Standard deviation, $\sum S, \sum S_r$, L and U at different batching time.

Batching time (hrs)	K/S	Standard deviation of K/S	$\sum S$	$\sum S_r$	Unlevelness (U)	Levelness (L)
3	2.75	0.18	0.7	1	0.32	3.76
6	2.94	0.18	0.68	1	0.31	3.79
9	3	0.14	0.55	0.87	0.27	3.99
12	3.12	0.13	0.46	1.27	0.22	4.16
15	3.28	0.098	0.37	0.85	0.19	4.37
18	3.27	0.2	0.79	1.33	0.37	3.59

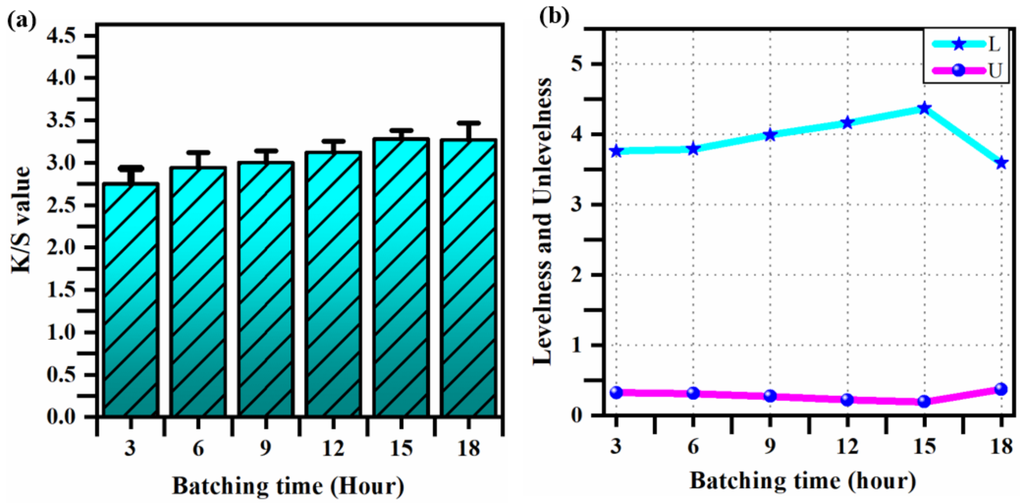

Figure 6: (a) K/S with SD and (b) L and U parameter at different batching time in cationic pad batch method.

3.3.3. Effect of binder concentration

K/S with SD, $\sum S, \sum S_r$, L, and U at different concentrations of binder OB45 for pigmentation in the pad batch method is shown in Table 5. Fluorescent pigments are insoluble and have no affinity for cellulose, and fixation is achieved by use of a binder which encloses them and provides a bond between pigment and fiber [7].

Statistical data are shown in Table 5. Figure 7a shows the effect of the concentration of Binder OB45 on shade depth with standard deviation. It is seen that K/S, along with standard deviation values, decreases with the increase of concentration of Binder OB45 from 14g/L to 80g/L At 14g/L binder concentration, maximum color strength 3.3 is obtained, and gradually the value decreases to 2.81 at 80g/L concentration. This happens as the epithelial membrane of the binder affects the light absorption and scattering of the coating particles [28]. So, a suitable concentration of binder is 14g/L according to the uptake of pigment.

By analyzing the value of standard deviation, it is found that higher color uniformity is obtained at 14g/L binder concentration. But it does not follow any order up to 80g/L concentration. Though by evaluating the data of standard deviation of K/S color uniformity can be assessed, a more accurate result can be obtained from the levelness and unlevelness parameters. Figure 7b depicts the L and U values as a function of Binder OB45 concentration. It is found that a higher L value is obtained at 4.36 at 14g/L concentration and gradually decreases to 0.19 with increasing concentration up to 80g/L, and following that, the U value follows the reverse order. This may be due to the probability of self-polymerization at higher concentrations reducing the levelness of fluorescent pigment [29].

Table 5: K/S with Standard deviation, $\sum S, \sum S_r$, L and U at different concentration of binder OB45.

Conc. of Forbind OB45 (g/l)	K/S	Standard deviation of K/S	$\sum S$	$\sum S_r$	Unlevelness (U)	Levelness (L)
14	3.3	0.09	0.48	0.67	0.19	4.36
26	3.28	0.13	0.5	0.77	0.2	4.28
40	3.12	0.14	0.62	0.85	0.25	4.03
54	3	0.14	0.61	1.29	0.26	4
67	2.97	0.15	0.46	1.43	0.28	3.88
80	3.81	0.17	0.46	1.65	0.3	3.81

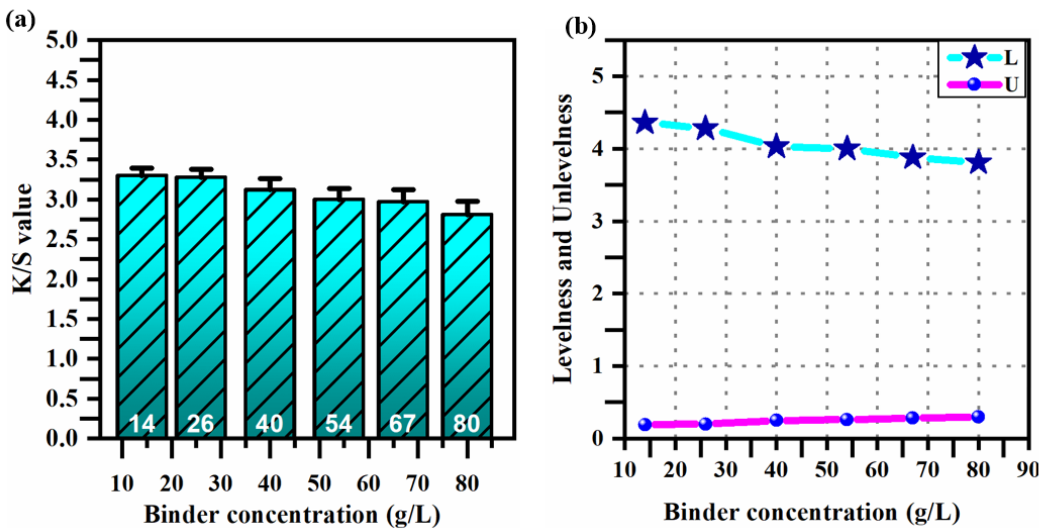

Figure 7: (a) K/S with SD and (b) L and U parameter at different concentration of binder in pad batch method

3.4 Testing of color performance

Table 6 demonstrates that the value of color fastness to water and perspiration (acidic and alkaline) and shows excellent results, but rubbing (dry and wet) and washing fastness do not provide satisfactory results. Also, the light fastness property does not meet the market demand. Ismail et al. found color fastness to water and perspiration (Acid and alkali) as 3/4 for fluorescent pigment dyed fabric while Acramin Prefix-K was used as cationizer [15]. Compared to these outcomes, better performance is achieved for the CTAC-modified fluorescent pigment dyed fabric.

Table 6: Fastness properties of treated fabric obtained from the pad batch method

Methods	Color fastness to						
	Water	Wash	Perspiration (Acidic)	Perspiration (Alkaline)	Rubbing		Light
					Wet	Dry	
Change in color rating							
Pad batch method	5	2	5	5	2/3	3/4	2

3.5 Assessment of the mechanical properties of fabric

Outcomes of tensile strength and elongation of fluorescent pigment dyed fabric explicate a significant enhancement in comparison with the untreated one. The data achieved from the stiffness tester indicates that the fabric is stiffer than the undyed fabric due to the presence of CTAC and binder film formation. Ibrahim et al. also found that the increment of tensile strength and reduction of fabric softness due to the incorporation of pigment on fabric [30]. The bursting strength of fluorescent pigment dyed fabric is reduced slightly compared with the pristine one. This observation is very inconvenient with Hossain et al., as they also found the reduction of the bursting strength of fluorescent pigment dyed fabric [6]. Finally, it can be pointed out that the cationizer, fluorescent pigment and binder have a significant positive influence on tensile strength and negligible negative effect on bursting strength and softness.

Table 7: Mechanical properties of untreated and treated fabric

Sample	Tensile strength (N)		Elongation %		Busting Strength (PSI)	Bending length (cm)
	Wales	Courses	Wales	Courses		
Untreated	213±12.23	130.5±4.02	60.4±3.32	131.3±0.21	67.34±3	1.7±2.3
Dyed sample	215.47±16.5	134.84±2.8	62.62±5.2	133.65±0.48	66.63±2.9	2.9±3.3

4. Conclusion

Cotton knit fabric is pretreated with cationizer CTAC and then dyed in the pad batch method with fluorescent pigment. Then, statistical parameters like standard deviation of K/S, levelness L, and unlevelness U values are measured and investigated to determine the influence of CTAC adsorption conditions like pH, CTAC concentration and also pigmentation conditions such as pH, batching time and binder concentration for the differently treated methods.

FTIR analysis of scoured, bleached, and CTAC adsorbed cotton confirmed the adsorption of cationic surfactant to the negatively charged cellulose fiber, which furthermore provided the dispersion stability of fluorescent pigment and thus ensured the level dyeing.

The results displayed at pH 9 and concentration 54g/L CTAC showed that the adsorption of CTAC was higher during cationization. Besides, pigmentation parameters mainly neutral pH, 15 hours batching time and 14 g/L binder concentration provided maximum K/S 4.3 with minimum standard deviation 0.09 and the highest levelness (L) 4.36 and the lowest unlevelness (U) 0.19 value. Though water, perspiration and dry rubbing fastness provided satisfactory results, light, wash and wet rubbing fastness did not meet market demand. In addition, the outcomes of tensile strength are satisfactory with negligible reduction of bursting strength and fabric softness.

Finally, it can be said that the utilization of CTAC cationizer in the pad batch method imparts significant levelness to the fluorescent pigment dyed fabric that can be used for aesthetic fashion and functional purposes such as sportswear, workwear, leisurewear, traffic police's clothing, children's clothing, and travel clothing, where enhanced visibility is essential.

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