COLOR CO-ORDINATES AND RELATIVE COLOR STRENGTH OF REACTIVE DYE INFLUENCED BY FABRIC GSM AND DYE CONCENTRATION

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Abstract

Role of dye concentration as well as fabric GSM on relative color strength and color coordinates were examined by spectral analysis. Spectral analysis of cotton fabric dyed with C.I. Reactive Yellow 145 has recorded maximum absorption at 430nm wavelength by using Kubelka-Munk theory, which allows the prediction of spectral reflectance of colorants in terms of absorption and scattering coefficients at same wavelength. The dyed fabric samples were tested in Datacolor 650(reflectance spectrophotometer) to get the difference in color coordinates (DL, Da*, Db*, DC* and DH*). This paper focused on the effects of fabric GSM and dye concentration on color coordinates and relative strength of color. The color strength of a dyed fabric is usually expressed by its k/s value. Color strength of dyed samples is relatively increases with the increase of fabric GSM and this value indicates maximum at higher GSM. On the other hand, color coordinates also changed as the changes with fabric GSM and dye concentration. Fabrics became darker when the colorant concentrations increased. Samples showed evidence of more redness and yellowness than the standard. Saturation level of dye also influenced positively in most cases i.e more intensive in higher areal density (GSM) of fabric.*

Keywords: *Color coordinates, Relative color strength, Illuminant, Saturation, Color temperature, Reactive dye.*

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1. INTRODUCTION

Color has been playing a leading role in human life from prehistoric time when people recognized the necessity of cloth to protect their body. Nature was the main source to decorate their cloths by extracting dyes from natural coloring matters. However, the extraction methods, accessibility and application processes were laborious and time consuming, so the use of synthetic dyes is getting the uttermost position. In the present day Reactive dyes are the prime choice and extensively used for dyeing any cellulosic fibre including cotton among all other synthetic dye in textile industries. The reactive dye becomes an integral part of fibre by forming a strong covalent bond between the dye molecules and the terminal hydroxyl group of cellulose. Dye-fibre bond formation is encouraged by alkali. As reactive dyes are anionic in nature and cellulose also contains hydroxyl group, salt works as electrolyte to neutral the fibre surface and promote dye exhaustion. During dyeing, the reaction takes place between the reactive group of such dye and water with increase in temperature, which results on the loss of dyes. This phenomenon is known as dye hydrolysis [1].

Color is an aspect of visual perception dependent on the spectral composition of observed radiant energy. Color practiced as a characteristic of a surface. Hue, Saturation and lightness are the three main attributes of a surface color. Hue permits a certain color to identify of an object as red, blue, yellow, green and so on. Saturation is the intensity of a color i.e. vividness or dullness of color, which also known as Chroma. Lightness is the quality of color which describes its luminous intensity-degree of lightness i.e. black (total absorption) or white (total reflection) [2].The color coordinates were measured by using CIE LAB due to having its widespread use. The CIELAB scale generally gives better approximation to visual evaluation of color difference for very dark colors and expands the yellow region of color in comparison with Hunter L, a, b scale. Both scales are mainly based on opponent color theory [3,4].The color of a substance is only perceived with the presence of an object, an illuminant from which light falls on it and gets reflected or transmitted (or both) and our eye on which the reflected or transmitted light falls. A light source is an object that emits light**,** whereas an illuminant is not a physical matter it only a demonstration of a light's spectral power distribution curve. To measure the color of a substance a standard spectral power distribution curve must be included for using a standardized method. The spectral data for these illuminants are stored in color measurement instruments to compute the object's color. CIE has introduced several illuminants to measure an object's color at certain light sources such illuminant D65 (average day light; correlated color temperature of 6500K and power of 18 W), illuminant TL83(Warm white Fluorescent, American Standard; correlated color temperature of 3000K and power of 18 W) and A(Incandescent light with a correlated color temperature of 2856K, power 40W)etc [5]. D. Hilbert, who studied on color constancy and complexity of color, where he observed the types of scenes and ranges of illuminants for

approximate constancy can be achieved and mechanisms that produce constancy [6]. Color constancy is the ability to perceive colors of objects i.e. the color is invariant of the light source. J. N. Yang et al, also observed the effects of illuminant cues in surface color perception by using the illuminant cues such as specular highlight, full-surface specularity and uniform background [7].

The areal density of fabric namely GSM (gram per square meter) is a structural properties of fabric. Rahman M. et al, who studied on effect of shade percentage on various properties such as GSM, CPI, WPI, shrinkage and color fastness properties of cotton knitted fabric dyed with reactive dyes, where all the properties of fabric were increased with the increases of shade percentage but the color fastness ratings decreased [8].Abu NaserMd. Ahsanul Haque observed the effects of electrolyte and liquor ratio on exhaustion and color co-ordinates of single jersey knitted fabric with bi-functional Fluorochloro Pyrimidene (FCP), bi-functional Monochlorotriazine-Vinylsulphone (MCT-VS) and mono functional Monochlorotriazine (MCT) reactive dyes [9].He also showed in another paper, the influence of alkali and temperature on fixation and color co-ordinates of different reactive dyes on single jersey knitted fabric [10].In this research we want to evaluate the effect of fabric GSM and dye concentrations on relative color strength and color co-ordinates (lightness, saturation and hue) of single jersey knitted fabric dyed with reactive dye.

2. MATERIALS AND METHODS

2.1 Materials and Sample Preparation

For this investigation single jersey scoured-bleached knitted fabrics were collected from Micro Fibre Group, Bangladesh. Fabrics were made from 100% cotton yarn and the areal density (GSM) of the fabrics was 120,160,180 and 200.The spectrophotometer also used in this study is Datacolor 650 (reflectance spectrophotometer). For this analysis eight pieces of fabric samples were taken, each one weights 5 grams. The samples were used for dyeing with Kiractive Yellow SP-3R, whose specification is given in Table 1.The dye has maximum absorbance (λ_{max}) at 430 nm and its chemical structure is shown in Figure 1.

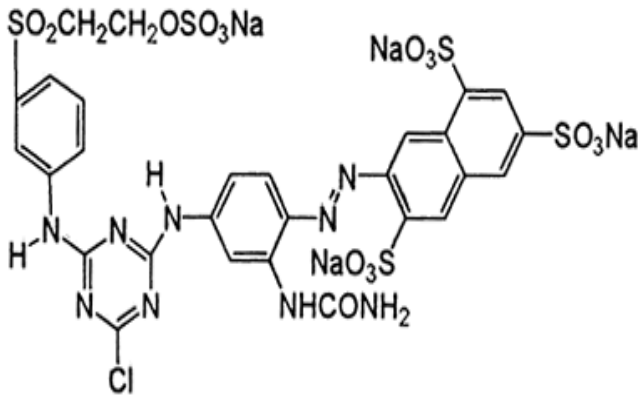


Fig-1: Chemical structure of C.I. Reactive Yellow 145

Table-1: Dye specification

Name	C.I. Reactive Yellow 145
Molecular structure	Single azo class
Reactive group	Vinyl sulphone
Molecular formula	$C_{28}H_{20}ClN_9Na_4O_{16}S_5$
Molecular Weight	1026.25

All other reagents were of the grade of general laboratory purpose. We dyed the samples by variation in shade percentage of 0.5%, 1% and 2%owf (on the weight of fabric). The dyeing recipe followed for the standards are mentioned in Table 2.

Table-2: Recipe of Reactive Dyeing

Description	**Kiractive Yellow SP- 3R**		
Dye conc.(%)	0.50%	1%	2%
Glauber salt (g/L)	30	45	50
Soda Ash (g/L)	12	12	18
Temperature^{o} C	60		
Time (min)	60		
pH	9.5		
M:L	1:8		

2.2 Sample Analysis

After the completion of dyeing process, the dyed samples were analyzed by Datacolor 650 (reflectance spectrophotometer).For sample analysis 120 GSM fabric in all cases i.e. 0.5%, 1% and 2% was taken as standard and we compared the color coordinate values and relative color strength with respect to such fabric for each dye concentration. All the tests were performed in D65 as standard illuminant for measuring the color coordinates (Hue, Lightness and Saturation).

Color strength is a measure of the ability of a dye to impart color to materials. The color strength is evaluated by light absorption in the visible region of the spectrum. Relative color strength can be defined as the ratio of K/S values for samples as compared to a standard at same wavelength, which expressed as percentage. 'K' and 'S' are absorption and scattering coefficients of dyed sample. Relative color strength (%) is calculated from reflectance, R using Kubelka-Munk equation as follows:

$$K/S = (1-R)^2/ 2R.$$

3. RESULTS AND DISCUSSION

3.1 Influence on Relative Color Strength

Table 3 and 4 shows that the relative color strength was influenced by fabric GSM as well as dye concentration. The relative strength increased with the increases with fabric GSM in all conditions. For example, when dye concentration was 0.5%, color strength increased with greater GSM. On the other hand, this value was also greater when dye concentration were increased. For same GSM, the relative strength of dye was gradually raised than before concentration.

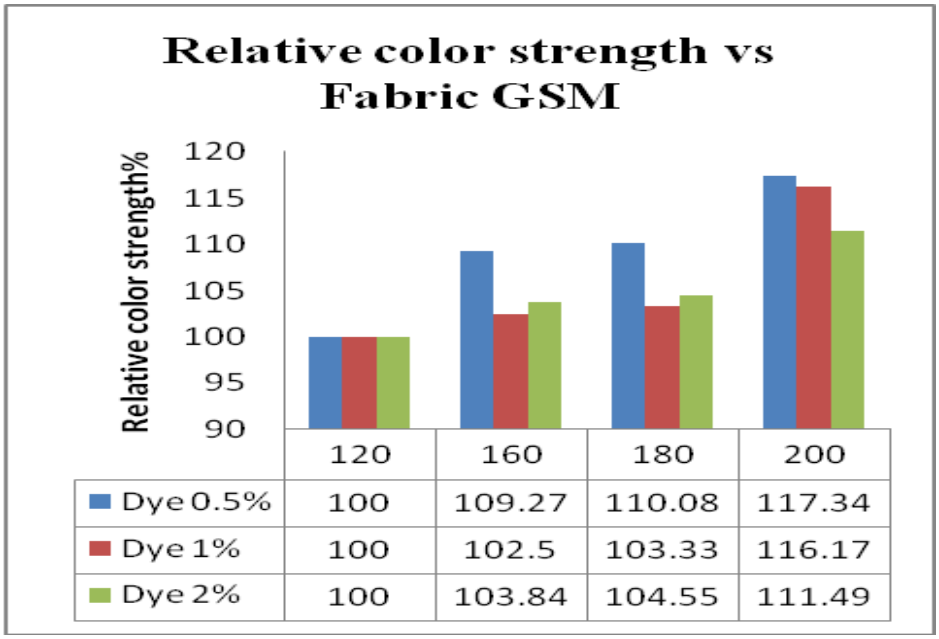


Fig-2: Influence of Fabric GSM on relative color strength

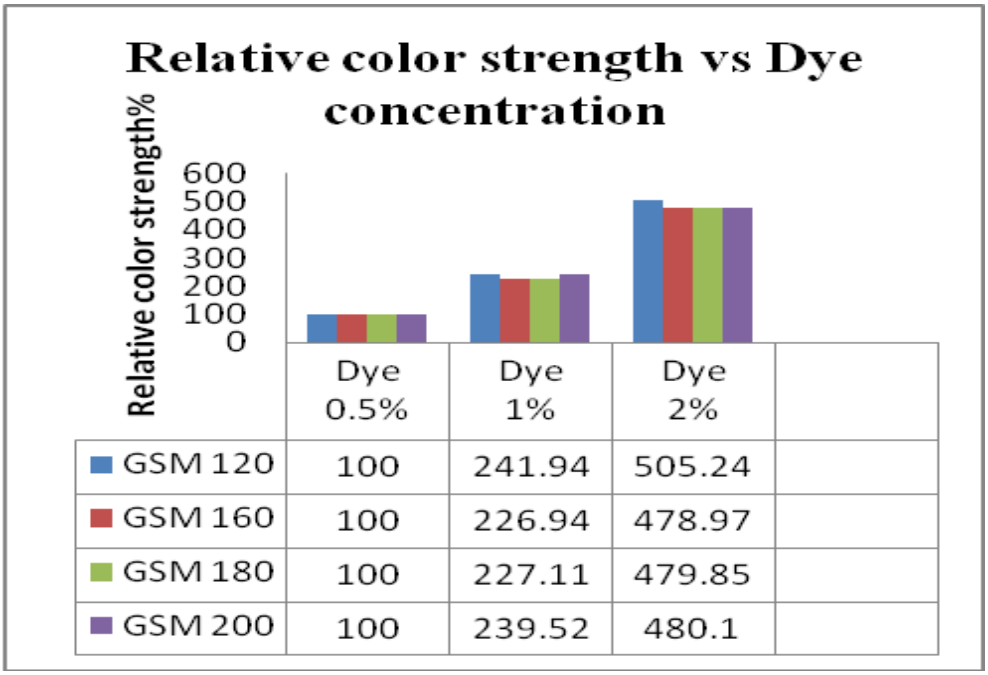
From the above bar diagram we can observe that the relative color strength was found highest value for 200 GSM in all cases. This diagram indicates higher relative strength with higher fabric GSM.

Table-3: Relative color strength of dyed fabrics (on the basis of fabric GSM)

Dye conc.	Fabric GSM	R_{min} %	K/S value	Relative Color Strength %
0.50%	120	14.68	2.48	100
	160	13.72	2.71	109.27
	180	13.65	2.73	110.08
	200	13	2.91	117.34
1%	120	7.12	6	100
	160	7	6.15	102.5
	180	6.96	6.2	103.33
	200	6.3	6.97	116.17
2%	120	3.7	12.53	100
	160	3.58	12.98	103.84
	180	3.55	13.1	104.55
	200	3.345	13.97	111.49

Table-4: Relative color strength of dyed fabrics (on the basis of dye concentration)

Fabric GSM	Dye conc. (%)	R_{min} %	k/s value	Relative Color Strength %
120	0.50%	14.68	2.48	100
	1%	7.12	6	241.94
	2%	3.7	12.53	505.24
160	0.50%	13.72	2.71	100
	1%	7	6.15	226.94
	2%	3.58	12.98	478.97
180	0.50%	13.65	2.73	100
	1%	6.96	6.2	227.11
	2%	3.55	13.1	479.85
200	0.50%	13	2.91	100
	1%	6.3	6.97	239.52
	2%	3.345	13.97	480.1



	Dye 0.5%	Dye 1%	Dye 2%	
GSM 120	100	241.94	505.24	
GSM 160	100	226.94	478.97	
GSM 180	100	227.11	479.85	
GSM 200	100	239.52	480.1	

Fig-3: Influence of Dye concentration on relative color strength

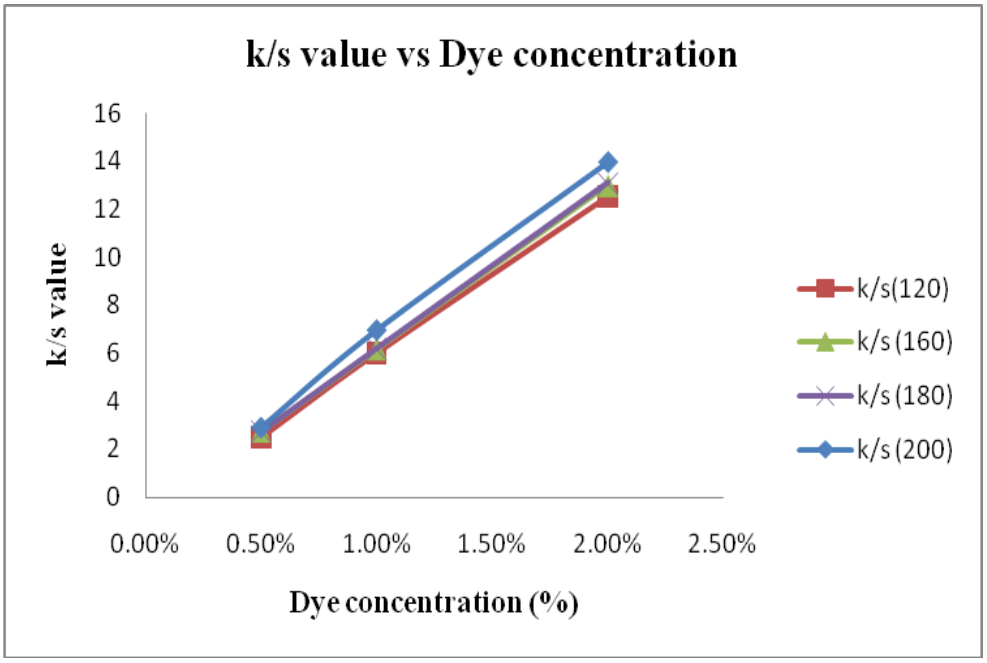


Fig-4: Influence of dye concentration on k/s value

Figure 3 and 4 shows that the relative color strength and k/s values increases with the increase of dye concentration, which indicates more dye uptake with greater concentration.

3.2 Influence on Color Coordinates

The color coordinates changes with the changes of dye concentration and fabric GSM. Figure 5 and 6 shows that the difference in lightness (DL*) were always negative so the shade were darker than the standard in all cases. The difference in saturation were observed more but less saturation were also found in 180 GSM for 1% concentration and 160, and 200 GSM for 2% concentration.

Table-5: Color coordinates of Dyed Fabrics

Dye conc.%	Fabric GSM	DL*	Da*	Db*	DC*	DH*
0.50%	120	Standard				
	160	-0.34	0.97	0.26	0.19	-0.63
	180	-0.3	1.11	0.35	0.23	-0.68
	200	-0.45	1.73	1.57	0.72	-0.89
1%	120	Standard				
	160	-0.47	1.06	0.7	0.34	-0.52
	180	-0.42	1.04	0.95	0.38	-0.46
	200	-0.43	-0.92	-1.01	-0.41	0.35
2.00%	120	Standard				
	160	-0.3	-0.58	-0.27	-0.15	0.3
	180	-0.49	2.17	0.79	0.51	-1.18
	200	-0.67	-0.37	-2.11	-0.65	-0.37

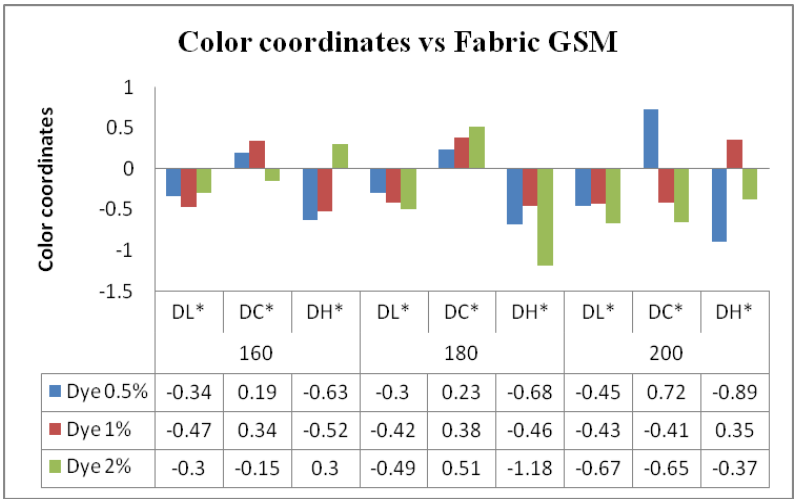


Fig-5: Influence of fabric GSM on the color coordinates

The changes in hue are shown in figure 5 by DH* and its tendency towards a specific color (such as red, yellow or blue) can be explained by the Da* and Db* values in Table-5. The color coordinates Da* and Db* in Table-5 shows that the shades were more reddish and more yellowish than the standard in maximum cases.

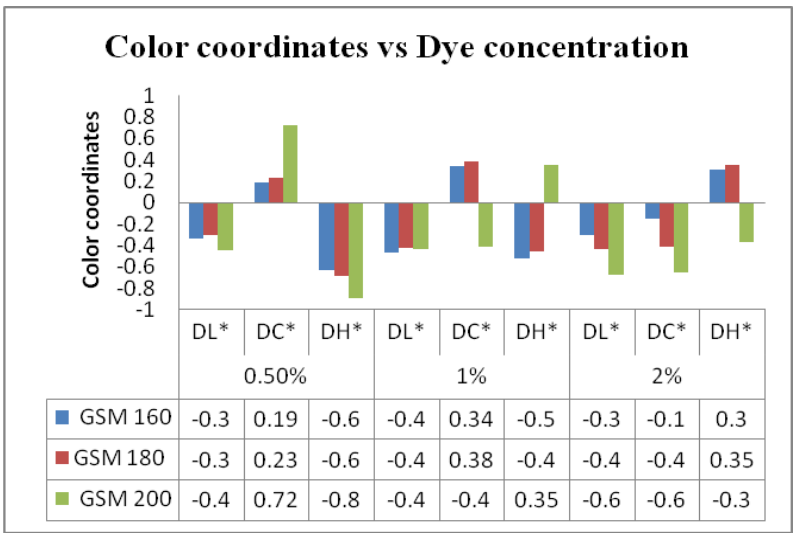


Fig-6: Influence of dye concentration on the color coordinates

4. CONCLUSION

The human eye can only detect small differences in any object color but now-a-days instrumental measurements are done widely in our industry to overcome this problem and for quantifying color accurately. The results of our investigation allow us to suggest that the relative strength of color and color coordinates of dye fabric increase with the increase of shade depth and fabric GSM. The dye-ability (K/S) reached maximum values at higher GSM as well as dye concentration. There may be the reason due to more dye uptake at higher concentration and greater number of fibre contains on fabric at higher value of GSM.

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BIOGRAPHIES

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