

# STUDIES ON THE COLOR DIFFERENCE ( $\Delta E$ ) OF THE SINGLE JERSEY KNIT FABRIC BY DIFFERENT CONCENTRATION OF NaOH

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**Abstract:** Most of the knitted cotton fabric is scoured and bleached with caustic soda and hydrogen peroxide and dyed with reactive dye. For this reason caustic soda was used for scouring and sumifix yellow 3RS was used for dyeing of cotton fabric. To carry out the experiment 2.5, 3.0, 3.5 and 4.0 g/l concentration of NaOH was used to obtain the proper effect. Finally the samples were dried and tested to evaluate the performance. The experiment that was carried out for measuring the color difference with the help of spectrophotometer. To carry out the experiment 2.5g/l NaOH was taken as standard and compared with others concentration e.g. 3.0, 3.5 and 4.0 g/l. It was found that as the concentration of NaOH increases, color difference decreases significantly. However for the economic point of view, best result obtained for 3 and 3.5 g/l of caustic soda. The experiments are done in Fakir Apparels Limited during my thesis work at 22<sup>nd</sup> may 2012.

**Keywords:** Color, spectrophotometer,  $\Delta E$  (color difference), NaOH, (caustic soda).

## 1. Introduction

Color as an aspect of visual perception dependent on the spectral comparison of observed radiant energy<sup>[1]</sup>. It is a physical impression of human mind. Modern concept of color was founded by Isaac Newton<sup>[2]</sup>. Newton was separated white day light into a sequence of colored light called 'spectrum', Violet-Indigo-Blue-Green-Yellow-Orange-Red and spectral range/visible range/spectral distribution 400-700 nm. There are three properties to color. First is hue, which simply means the name a color. The second property is intensity, which refers to the strength and vividness of the color described as bright or dull. The third and final property of color is value meaning lightness or darkness<sup>[3]</sup>. The committee on colorimetry of the optical

society of America defined color<sup>[4]</sup> "Color is the general name for all sensations arising from the activity of the retina of the eye and its attached nervous mechanism, this activity being in nearly every case in the normal individual, a specific response to radiant energy of certain wavelength and intensity." Light is an electromagnetic radiation that can be perceived by the human eye and its electromagnetic waves with wavelengths between  $4 \times 10^{-7}$  and  $7 \times 10^{-7}$  meters. Electromagnetic<sup>[5]</sup> radiation has a dual nature as both particles and waves. When changing electric and magnetic fields, forming an electromagnetic wave. This wave has amplitude, which is the brightness of the light, and wavelength which is the color of the light, and an angle at which it is vibrating, called polarization. An electromagnetic wave has a frequency  $f$ , a speed  $v$  and a wavelength  $\lambda$ , which are related by the equation  $v=f\lambda$ . In vacuum or in air, the speed  $v = c$  (speed of light:  $3 \times 10^8$  m/s) so the relationship would be  $c=f\lambda$ <sup>[6]</sup>

Color difference ( $\Delta E$ ): In CIE  $L^*, a^*, b^*$  space, the color difference between a standard and a trial sample is expressed numerically  $\Delta E$ <sup>[7]</sup>

$$\Delta E = \left( \Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2} \right)^{\frac{1}{2}}$$

$$\text{where, } \Delta L^* = L_T^* - L_S^*$$

$$\Delta a^* = a_T^* - a_S^*$$

$$\Delta b^* = b_T^* - b_S^*$$

Where, the subscripts T and S denote trial and standard samples respectively. The color difference can also be specified in terms of coordinates  $L^*, C^*$  and  $H^*$  where  $C^*$  represents Chroma and  $H^*$  represents hue angle

$C^*$ = the distance between the sample and L-axis  
 $H^*$ = the angle made by the chroma line and a\* axis.

The total color difference (in CIELCH system)<sup>[8]</sup>

$$\Delta E = \left( \Delta C^{*2} + \Delta H^{*2} + L^{*2} \right)^{\frac{1}{2}}$$

CIE recommended the CIE  $L^*a^*b^*$  system. The system is intended to be a uniform color space with the following properties<sup>[9][10]</sup>

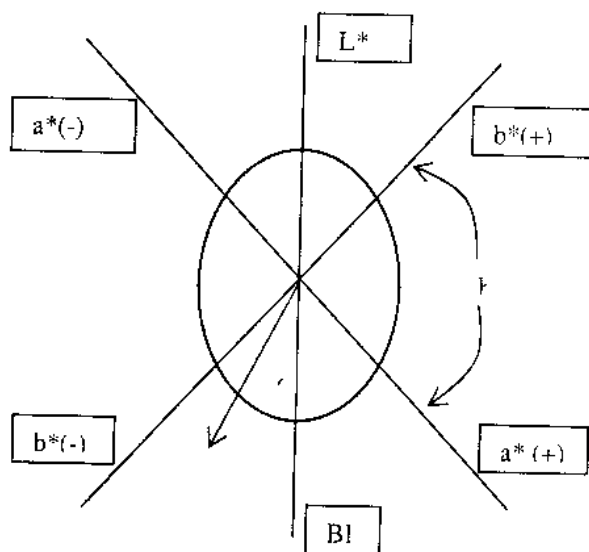
- (i) A rectangular, three dimensional color space ( $L^*a^*b^*$ ) in which all surface colors can be represented.
- (ii) The distance between the points representing the colors of two samples is proportional to the visual color difference between them.
- (iii) The axes are scaled so that color difference is represented by unit distance.
- (iv) The  $L^*a^*b^*$  values can be easily interpreted in terms of the hue, lightness and depth of shade.

$L^*$  is the vertical axis and represents lightness. 0 being a perfect black and 100 a perfect white.

$a^*$  an axis in the plane normal to L which represents the redness/greenness quality of

the colour, positive values denote redness and negative values denote greenness

$b^*$  an axis normal to both L and a which represents the yellowness/blueness quality of the colour, positive values denote yellowness and negative value denote blueness.



## 2. Experimental work

### Recipe of Scouring and Bleaching

Chemicals	Conc.	Conc.	Conc.	Conc.
	Sample 1	Sample 2	Sample 3	Sample 4
Wetting agent (CK)*	0.5 g/l	0.5 g/l	0.5 g/l	0.5 g/l
Sequesting agent, (Tex-D-900)*	0.5 g/l	0.5 g/l	0.5 g/l	0.5 g/l
Antifoaming agent, (FFC)*	0.5 g/l	0.5 g/l	0.5 g/l	0.5 g/l
Scouring chemical Caustic	2.5.0 g/l	3.0 g/l	3.5.0 g/l	4.0 g/l
Bleaching agent, $H_2O_2$	4g/l	4g/l	4g/l	4g/l
Stabilizer (CentableachSOF)*	0.5g/l	0.5g/l	0.5g/l	0.5g/l
Per oxide killer (Crocks)*	0.5g/l	0.5g/l	0.5g/l	0.5g/l
Acetic Acid	0.5g/l	0.5g/l	0.5g/l	0.5g/l
Temperature	95c	95c	95c	95c
Time	60 min	60 min	60 min	60 min
L:R	1:8	1:8	1:8	1:8

\*Commercial Name

### 2.1. Procedure of scouring

- (i) Wetting agent, sequestering agent and antifoaming agent were put in the dyeing bath at room temperature
- (ii) Then peroxide and stabilizer were added in the dye bath at 40° C.
- (iii) Then alkali was added in the dye bath and the temperature was raised to 98°C from room temp @ 2.5°C/min.
- (iv) The dyeing bath was run for 60 minutes at 98°C.
- (v) Then bath temperature was lowered down to 70-80°C from 98° C.
- (vi) Then rinsing was done in hot water twice (around 70°C) and washing was done in cold water. Then temperature was raised to 80° C and at that temperature crocks was applied for removing residual H2O2.
- (vii) At last acetic acid was applied for neutralizing the dyeing bath.

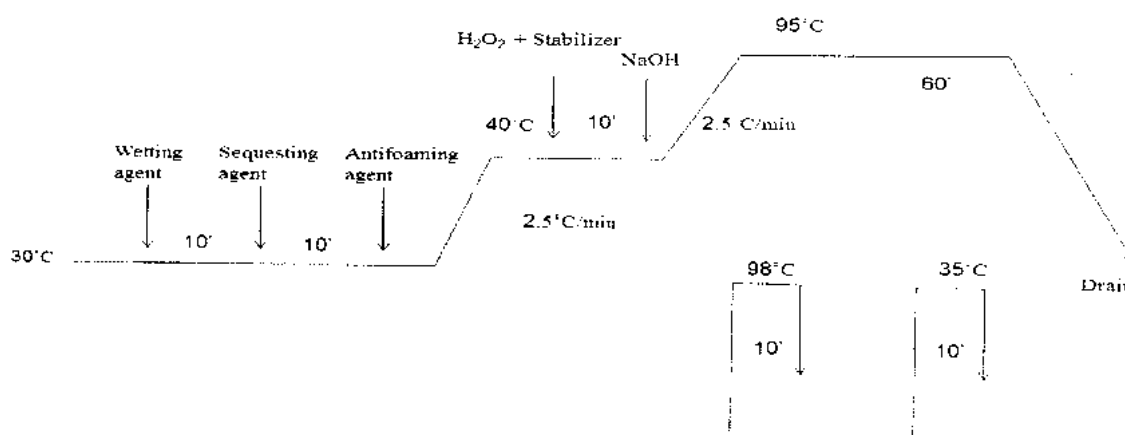


Figure 1 : Curve of scouring and bleaching of cotton fabric

### 3. Dyeing

Dyeing was carried out in the same bath after scouring and bleaching.

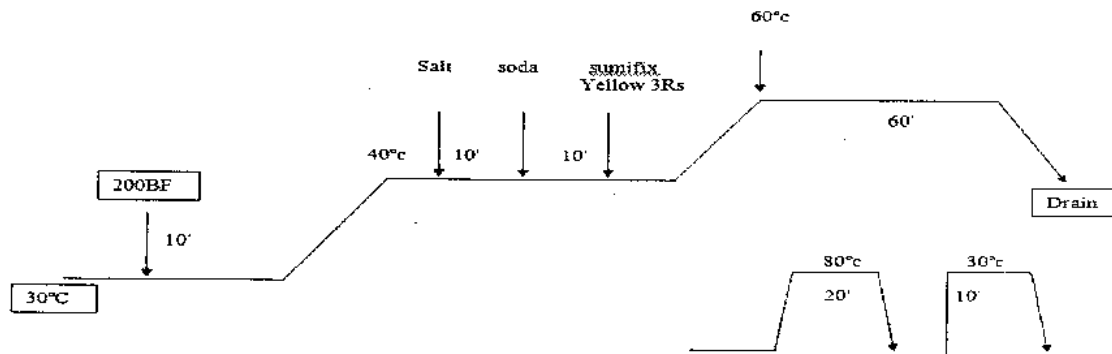
#### 3.1 Recipe of dyeing

Chemicals	Amount
Reactive dye (Sumifix Yellow 3RS)*	2%
Levelling agent(200BF)*	1g/l
Salt Soda	10g/l
L: R	1:8
Temperature	60°c
Time	60 min

\*Commercial name

#### 3.2 Procedure of dyeing

- (i) Leveling agent was applied in the dyeing bath at room temperature.
- (ii) The dyeing bath was continued for 10 min at room temperature.
- (iii) The temperature was raised to 40° C and salt was applied at that temperature.
- (iv) Then the dyeing bath was run for 10 min at 40° C.
- (v) After 10 min soda ash was added at 40° C and the bath was running for 10 min.
- (vi) Then the temperature was raised to 60° C and sumifix dye was added at that temperature.
- (vii) The whole bath was kept for 60 min at 60° C for dyeing,
- (viii) The temperature was dropped to 30°C from 60° C for cooling the bath.
- (ix) Then rinsing was done in hot water twice (around 70°C) and washing was done in cold water.
- (x) At last acetic acid was applied for neutralizing the dyeing bath.



**Figure 2 :** Curve of cotton fabric dyeing with reactive dye

#### 4 Drying

Then the fabric were dried with the help of iron

#### 5. Testing

After drying all the four classes of samples were tested to evaluate their performances. In this regard the following tests was carried out color difference( $\Delta E$ )

#### 6. Measurement the color difference

The differences of color among the four different samples were tested by using a CCMS color measuring instrument. The test were carried out in Fakir Apprels Ltd .Further details are given below

##### 6.1 Procedure

- (i) First calibration was done
- (ii) Then the 1<sup>st</sup> fabric was clamped in the spectrophotometer and was taken it as a standard.

(iii) Then 1<sup>st</sup> fabric was taken off.

(iv) Then 2<sup>nd</sup> fabric was clamped and was taken the readings.

(v) After that the 2<sup>nd</sup> fabric was taken off and the 3<sup>rd</sup> sample was clamped.

(vi) Then reading was taken for 3<sup>rd</sup> sample.

(vii) Then the 3<sup>rd</sup> fabric was taken off.

(viii) And the 4<sup>th</sup> fabric was clamped and the readings was taken for 4<sup>th</sup> fabric.

And all measurement is done with the standard of 1<sup>st</sup> sample.

**Result**

**Table 1 CCMS data of sample 2**

**FAKIR APPARELS LIMITED**

142-45A, BSCIC Hosiery Industrial Estate,

Shahangaan, Fatullah, Narayanganj-1420, Bangladesh.

Today's Date: 22-May-12

**LAB ANALYSIS & QC**

**Warn**

CMC DE = 0.82

CMC Commercial Factor = 1.00

CMC1 = 2.00 CMC c = 1.00

Standard Name

18 o 18

0

Measured on: 22-May-12 at 21:06:40 Inst Cond: %R

Spectral Data: Std.

400-450 nm	3.61	3.52	3.67	3.69	3.64	3.62
460-510 nm	3.61	3.49	3.33	3.24	3.12	2.93
520-570 nm	2.70	2.48	2.34	2.20	2.06	1.99
580-630 nm	1.97	1.96	1.97	2.01	2.05	2.15
640-690 nm	2.42	2.89	3.92	5.86	9.41	14.19
700 nm	20.86 (checksum = 143.35)					

Primary Illuminant

D65 10 Deg

Batch Comments

lighter  
less saturated  
more green

Batch Name

10 1

**BATCH**

Measured on: 22-May-12 at 21:07:01 Inst Cond: %R LAV SCTUV Cal

Spectral Data: Batch:

400-450 nm	3.62	3.68	3.74	3.76	3.70	3.72
460-510 nm	3.72	3.63	3.49	3.42	3.32	3.12
520-570 nm	2.87	2.62	2.45	2.28	2.13	2.04
580-630 nm	2.02	2.09	2.01	2.05	2.09	2.21
640-690 nm	2.51	3.01	4.19	6.37	10.25	15.41
700 nm	22.46 (checksum = 150.92)					

Metamerism Index:

Primary Illuminant: D65 10 Deg

D65 10 Deg vs. A 10 Deg: 0.30

D65 10 Deg vs. TL83 10 Deg: 0.17

Std. Wl. of Max. Abs.

Batch Wl. of Max. Abs.

Strength Diff: 96.34

Original Data:

Primary ill	CMC DE*	DL*	Da*	Db*	DC*	DH*	Standard		Batch		
							L	a	b	c	L
D65 10 Deg	0.82	0.46	-0.51	0.17	-0.21	-0.49	17.65	0.87	18.11	0.36	-7.61
A 10 Deg	0.49	0.42	-0.22	0.04	-0.06	-0.22	7.78	7.61	7.61	7.61	7.61
TL83 10 Deg	0.59	0.37	-0.36	0.10	-0.07	-0.36	276.38	272.73	272.73	272.73	272.73

Table 2 CCMS data of sample 3

**FAKIR APPARELS LIMITED**

142-45A, BSCIC Hosiery Industrial Estate,  
Shahangaan, Fatullah, Narayanganj-1420 Bangladesh.

Today's Date: 22-May-12

LAB ANALYSIS & QC

Pass

Standard Name 180 18

CMC DE = 0.72

0

CMC Commercial Factor = 1.00

Measured on: 22-May-12 at 21:06:40 Inst Cond: %R

CMC l = 2.00 CMC c = 1.00

Spectral Data / Std.

400-450 nm	3.61	3.62	3.67	3.69	3.64	3.62
460-510 nm	3.61	3.49	3.33	3.24	3.12	2.93
520-570 nm	2.70	2.48	2.34	2.20	2.06	1.99
580-630 nm	1.97	1.96	1.97	2.01	2.05	2.15
640-690 nm	2.42	2.89	3.92	5.86	9.41	14.19
700 nm	20.86	checksum = 143.35				

Primary Illuminant:

D65 10 Deg

Batch Comments:

lighter

less saturated

more green

Batch Name 10 1

**BATCH**

Measured on: 22-May-12 at 21:07:01 Inst Cond: %RLAV SCIUV cal

Metamerism Index

Spectral Data / Batch

400-450 nm	3.62	3.68	3.74	3.76	3.70	3.72
460-510 nm	3.72	3.63	3.49	3.42	3.32	3.12
520-570 nm	2.87	2.62	2.45	2.28	2.13	2.04
580-630 nm	2.02	2.09	2.01	2.05	2.09	2.21
640-690 nm	2.51	3.01	4.19	6.37	10.25	15.41
700 nm	22.48	checksum = 150.92				

Primary Illuminant: D65 10 Deg

D65 10 Deg vs. A 10 Deg: 0.10

D65 10 Deg vs. TL83 10 Deg: 0.17

Std. Wl. of Max. Abs.

Batch Wl. of Max. Abs.

Strength Diff: 96.34

Original Data:

Primary ill	CMC DE*	DL*	Da*	D <sub>b</sub> *	DC*	DH*	L	Standard	Batch
D65 10 Deg	0.72	0.36	-0.31	0.17	-0.11	-0.29	a	17.65	18.11
A 10 Deg	1.19	0.32	-0.22	0.04	-0.06	-0.22	b	7.78	7.61
TL83 10 Deg	0.92	0.37	-0.36	0.10	-0.07	-0.36	c	7.85	7.62
							h	276.38	272.75



**Table 3** CCMS data of sample 4

**FAKIR APPARELS LIMITED**

142-45A, BSCIC Hosiery Industrial Estate,

Shashangaon, Fatullah, Narayanganj-1420, Bangladesh.

Today's Date: 22-May-12

LAB ANALYSIS & QC

Pass

Standard Name 180 18

CMC DE = 0.52

0

CMC Commercial Factor 1.00

Measured on: 22-May-12 at 21:06:40 Inst Cond. %R

CMC1 2.00 CMC c 1.00

Spectral Data Std.

400-450 nm	3.61	3.62	3.67	3.69	3.64	3.62
460-510 nm	3.61	3.49	3.33	3.24	3.12	2.93
520-570 nm	2.70	2.48	2.34	2.20	2.06	1.99
580-630 nm	1.97	1.96	1.97	2.01	2.05	2.15
640-690 nm	2.42	2.89	3.92	5.86	9.41	14.19
700 nm	20.86	Checksum = 143.35				

Primary Illuminant

D65 10 Deg

Batch Comments

lighter  
less saturated  
more green

Batch Name 10 1

BATCH

Measured on: 22-May-12 at 21:07:01 Inst Cond. %R LAV SCTUV Cal

Metamerism Index

Spectral Data Batch

400-450 nm	3.62	3.68	3.74	3.76	3.70	3.72
460-510 nm	3.72	3.63	3.49	3.42	3.32	3.12
520-570 nm	2.37	2.62	2.45	2.28	2.13	2.04
580-630 nm	2.02	2.00	2.01	2.05	2.09	2.21
640-690 nm	2.51	3.01	4.19	6.37	10.25	15.41
700 nm	22.48	Checksum = 150.92				

Primary Illuminant D65 10 Deg

D65 10 Deg vs. A 10 Deg 0.30

D65 10 Deg vs. TL83 10 Deg 0.17

Std. Wl. of Max. Abs.

Batch Wl. of Max. Abs.

Strength Diff: 96.34

Original Data:

	CMC DE*	DI*	Da*	Db*	DC*	DIP*	L	Standard	Batch
Primary ill								17.65	18.11
D65 10 Deg	0.52	0.36	-0.11	0.07	-0.11	-0.29	a	0.87	0.36
A 10 Deg	0.50	0.32	-0.12	0.04	-0.06	-0.22	b	-7.78	-7.61
TL83 10 Deg	0.49	0.37	-0.16	0.01	-0.07	-0.36	c	7.83	7.62
							h	276.38	272.73

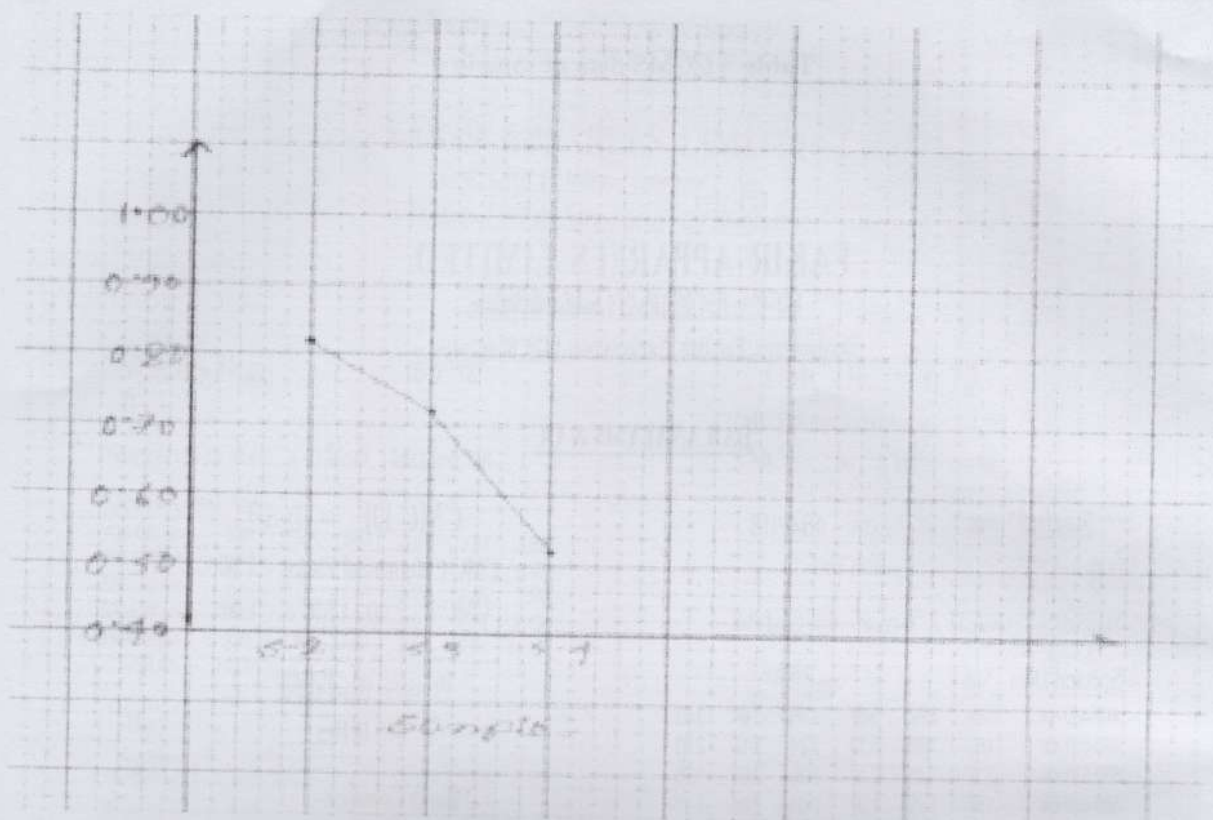


Figure 3 : Comparison the  $\Delta E$  value with standard sample 1 (Graphical representation)

Sample	dE	Result
Sample 2	0.82	Warn
Sample 3	0.72	Pass
Sample 4	0.52	Pass

Table-4 Comparison the  $\Delta E$  value with Standard Sample-1 (Obtained from tables 1,2&3)

### 10. Conclusions

Here caustic soda plays an important role on color difference ( $\Delta E$ ). Color difference gradually minimized when concentration of NaOH was changed from 3.0g/l to 4 g/l as 2.5 g/l was taken as a standard. But fabric losses its strength very fast as breakdown of cellulose unit. From all aspect better performance was obtained from 3g/l to 3.5 g/l.

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