International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

CIELAB Color Spaces of Reactive Dyed Cotton Fabric Predisposed by Correlated Color Temperature of Illuminant and Depth of Shade

Salima Sultana Shimo[†*]

[†]Department of Textile Engineering, Daffodil International University, Mirpur Road, Dhanmondi, Dhaka-1207, Bangladesh

Accepted 02 March 2015, Available online 13 March 2015, **Vol.5, No.2 (April 2015)**

Abstract

Color has a semantic content which touching directly our sentimental world. It has a significant influence on the aesthetic properties of textiles. Color is the result of dyeing a textile material depends on the chemical structure of the dyes and the physical and chemical properties. Manufacturers are expected to provide their material with a high level of quality in color so that it meets the needs of its customers. Role of illuminant and depth of shade on CIELAB color spaces were evaluated by Datacolor 650 (reflectance spectrophotometer) to get the difference in color spaces (DL, Da*, Db*, DC* and DH*) of reactive dyed fabric focused on this paper. The color spaces of dyed fabrics shows higher lightness at higher concentration usually expressed by DL*. Correlated color temperature of illuminant is maximum for D65 (6500K). Fabrics became darker when the colorant concentrations increased as well as illuminants CCT. 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 dye concentration and fabric GSM.*

Keywords: *Correlated color temperature, Color spaces, Color Build-up, Illuminant, Shade depth, Reactive dye.*

1. Introduction

Fibre Reactive dyes,class of highly colored organic substances which attach themselves to the substrates by a strong chemical reaction by forming a covalent bond between the molecule of dye and that of the fibre. The dyestuff thus becomes an integral part of the fibre and is difficult to be removed by washing that adhere by adsorption. Mainly cellulosic fibre dyeing with reactive dye significantly improves the product's color stability and wash ability. Thus reactive dying of cotton is currently the most pervasive dying process in the textile world. Dye-fibre bond formation is encouraged by alkali. Reactive dyes are anionic in nature and cellulose also contains hydroxyl group, salt used in dye bath, works as electrolyte to neutral the fibre surface and encourage dye exhaustion. During dyeing, under alkaline condition the reaction takes place between the reactive group of such dye and water instead of reaction with fibre, which results on the loss of dyes. This phenomenon is known as dye hydrolysis. The rate of this hydrolysis becomes greater when temperature increases. The effluent load becomes greater due to hydrolysis (A D Broadbent, 2001; Dr. V. A. Shenai, 1993).

Color can describe precisely by measuring the intensity of visible electro-magnetic radiation at many distinct wavelengths namely spectral power distribution (SPD).Visual perception of color mainly dependent on the spectral composition of observed radiant energy. Color practiced as a characteristic of a surface. The three key properties of a surface color are Hue, Saturation and lightness. Hue permits a certain color to identify of an object as red, blue, yellow, green and so on. Hue mainly distinguishes one surface color from another. Saturation is termed as strength of Hue or intensity of a color i.e vividness or dullness of color, it's another name is Chroma.

Lightness describes luminous intensity of color i.e. black (total absorption) or white (total reflection) (Deane B. Judd,1940). CIELAB is the most complete color space defined by the International Commission on Illumination which describes all the colors visible to the human eye and was shaped to provide as a device-independent model to be used as a reference. 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 (Application note,2001;V.K.Sikri,2010).

The three coordinates of CIELAB represent the lightness of the color (***L**** = 0 yields black and ***L**** = 100 indicates diffuse white, ***a****, negative values indicate green while positive values indicate red and ***b****, negative values indicate blue and positive values indicate yellow. The asterisk (*) after *L*, *a* and*b* are

*Corresponding author: **Salima Sultana Shimo**

Table 1 Dye specification

Name	C.I. Reactive Yellow 145	C.I. Reactive Red 195
Molecular structure	Single azo class	Single azo class
Molecular formula	$C_{28}H_{20}ClN_9Na_4O_{16}S_5$	$C_{31}H_{19}ClN_7Na_5O_{19}S_6$
Molecular Weight	1026.25	1136.32

Table 2 Recipe of Reactive Dyeing

Description	Reactobond Yellow 3RX 150%			Reactobond Red 3BX 150%		
Shade %	0.50%	1%	2%	0.50%	1%	2%
Glauber salt (g/L)	30	45	50	30	45	50
Soda Ash (g/L)	12	12	18	12	12	18
Temperature^0 C	60					
Time (min)	60					
M:L	1:08					

marked star and they represent *L**, *a** and *b**, which used to distinguish them from Hunter's *L*, *a*, and *b*. The spectral power distribution (SPD) of a blackbody radiator can be completely determined from color temperature in Kelvin (K).The correlated color temperature (CCT) of a light source is the temperature of an ideal black body radiator(a hypothetical body which absorbs all radiation falling on it) that radiates light of comparable hue to that of the light source. The CCT rating indicates the warmer and colder of the light source (R. Davis,1930; L. Johansson,2004).

An illuminant from which light falls on a substance and gets reflected or transmitted (or both) and our eye on which those reflected or transmitted light falls the color is only perceived with the presence of an object. An illuminant is not a physical matter where a light source is an object that emits light. 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 such illuminant D65 (average day light; correlated color temperature of 6500K and power of 18 W),illuminant TL83(Warm white Fluorescent, American Standard;cor related color temperature of 3000K and power of 18 W) and A(Incandescent light with a correlated color temperature of 2856K, power 40W)etc (CIE Colorimerty).

Many researchers had studied different issues covering areas like: the effects shade percentage, of electrolyte and liquor ratio on exhaustion and color co-ordinates, alkali and temperature on fixation and color co-ordinates of different reactive dyes on single jersey knitted fabric (M. Rahman *et al*. 2008, A. N. M. A. Haque,2014). Another researcher studied correlation between hue-angle and colour lightness steamed Black locust wood, he found a good linear correlation between them (L Tolvaj *et al*.2008). In this research I want to evaluate the effect of illuminant and dye concentrations on CIELAB color spaces (lightness, saturation and hue) of single jersey knitted fabric dyed with reactive dyes.

2. Materials and Methods

Single jersey scoured-bleached 100% cotton knitted fabrics were used for this analysis, collected from Micro Fibre Group, Bangladesh. The areal density (GSM) of the fabrics was 120,160,180. The samples were dyed with Reactobond Yellow 3RX 150% and Reactobond Red 3BX 150% whose specifications are given in Table 1. The dyehas maximum absorbance (λ_{max}) at 430 nm and 550 nm respectively and chemical structures are shown in Fig. 1 and Fig. 2.All other chemicals were of the grade of general laboratory purpose. The dyeing recipe followed for the standards are mentioned in Table 2.

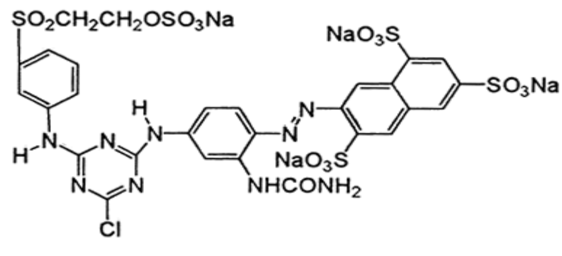

Fig.1 Chemical structure of C.I. Reactive Yellow 145

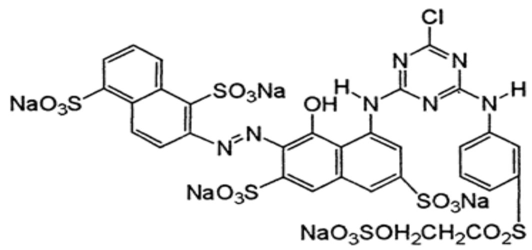

Fig.2 Chemical structure of C.I. Reactive Red 195

2.1 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 space values with respect to such fabric for each dye concentration and illuminant. All the tests were performed in D65, A and TL83 as standard illuminants for measuring the color coordinates (Hue, Lightness and Saturation).

3. Results and Discussion

3.1 Influence of Correlated color temperature of illuminant on CIELAB color spaces

Every illuminant has a specific correlated color temperature. The value of CIELAB color spaces significantly changed by viewing under different illuminant (light source). The lightness (DL*) and Hue (DH*) values were directly influenced by illuminant. The obtained results were recorded in the appendix (Tables I), where showed that the lightness values were slightly greater for higher correlated color temperature of illuminant whereas hue shows opposite results. It can be clearly defined as the illuminant, D65 has maximum CCT (6500K) than illuminant, A(CCT 2856K) and illuminant, TL83(CCT 3000K). The value of color spaces indicator DL* was greater at D65 for all cases i.e for all dye concentrations in comparison with illuminant, A and illuminant, TL83 but DH* decreases with the increase of correlated color temperature of illuminants. At maximum CCT (D65) the color space hue, DH* became less than other illuminants (A and TL83). Another color space, saturation (DC*) showed that the influence of illuminant was not in a regular manner i.e sometimes saturation was higher in D65 but not always in all conditions.

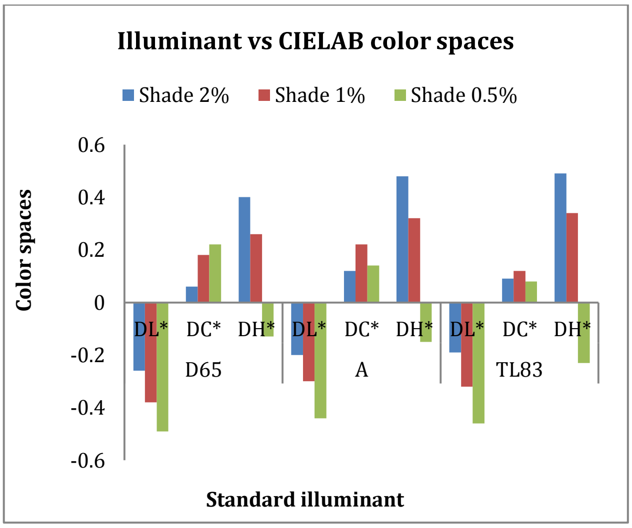

Fig. 3 CIELAB color spaces influenced by illuminants (fabric GSM 160- Red)

Figure 3 and 4 shows that the lightness, DL* was maximum at higher CCT (illuminant D65) than illuminant, A and TL83, which indicates the fabrics became darker in D65 . The darkness also greater when fabric GSM also higher. On the other hand hue, DH* decreased with higher CCT. Hue, DH* can be described by Da*(positive values indicates redness and negative values indicates greenness) and Db* (yellowness and blueness). At D65 the fabric became more red in all conditions and yellowness maximum at lower CCT (illuminant, A).

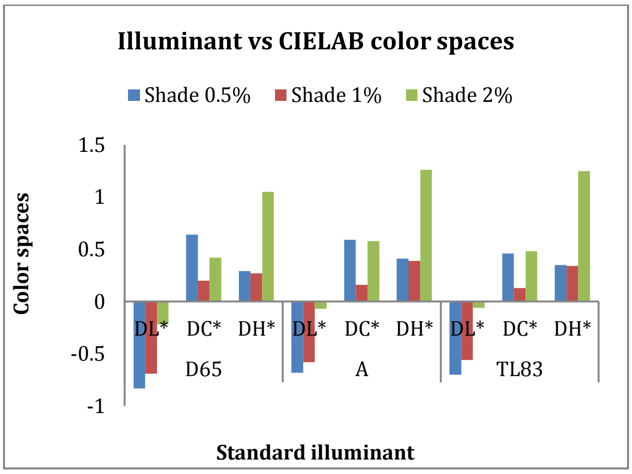

Fig.4 CIELAB color spaces influenced by illuminants (fabric GSM 180- Red)

Figure 5 and 6 showed that at higher CCT (illuminant D65) the lightness, DL* was maximum in all conditions than illuminant, A and TL83, which indicates the fabrics became darker in D65 . The darkness also influenced by GSM i.e more darkness appears when fabric GSM also higher. At D65 the fabric became more red in all conditions and sometimes yellowness maximum at lower CCT (illuminant, TL83) exceptional results also showed in case of 1% dye concentration.

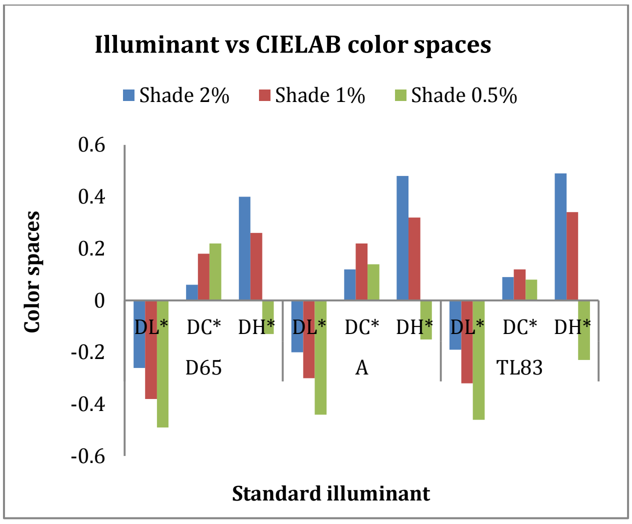

Fig. 5 CIELAB color spaces influenced by illuminants (fabric GSM 160- Yellow)

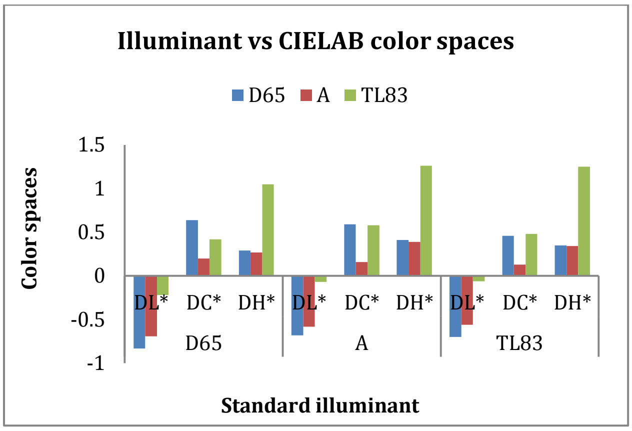

Fig.6 CIELAB color spaces influenced by illuminants (fabric GSM 180-Yellow).

3.2 Influence of Depth of shade on CIELAB color spaces

The color spaces changes with the change of depth of shade. The difference in lightness (DL*) was always negative so the shade were darker than the standard in all cases showed in the appendix (Table I). The difference in saturation was observed more but less saturation were also found in 180 GSM for 1% concentration.

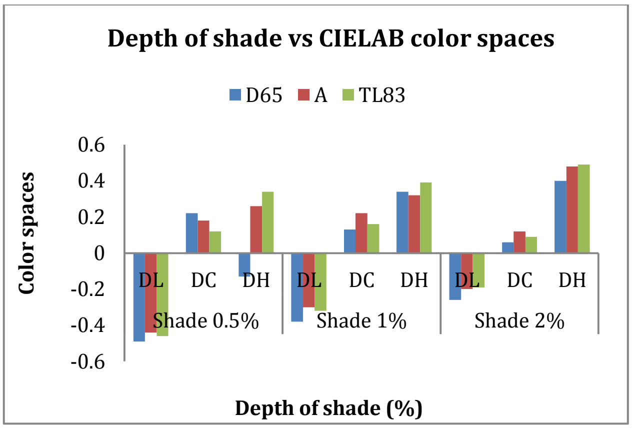

Fig. 7 CIELAB color spaces influenced by depth of shade (fabric GSM160- Red)

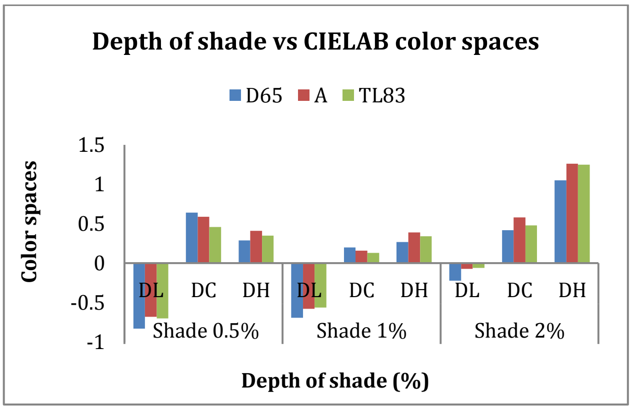

Fig.8 CIELAB color spaces influenced by depth of shade (fabric GSM180- Red)

From the figure 7 and 8 we observed that CIELAB color spaces increases with the increase of depth of shade as well as higher GSM, which indicates more color build-up (absorbs more dye at higher dye concentration and then reflection becomes minimum) as more number of fibre presents at higher GSM. The color spaces indicators (DL*,DC* and DH*) increases as dye concentration increases in all cases, which indicates fabric became more darker and more saturated at higher concentration. The appendix (Table I) shows that the shade became more red and more yellow at higher dye concentration than previous concentration as well as higher GSM when fabric dyed with Reactobond Red 3BX 150%.

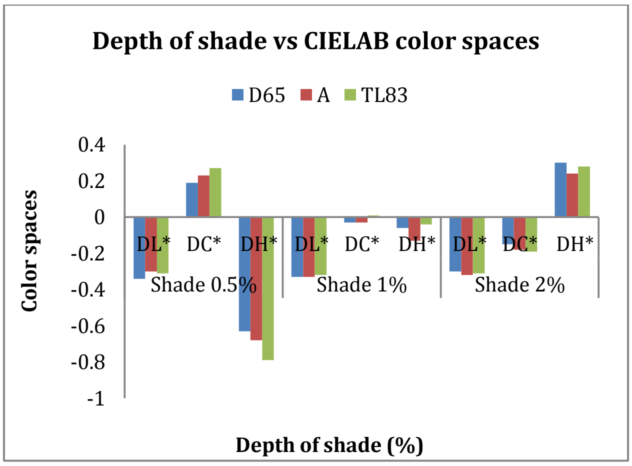

Fig. 9 CIELAB color spaces influenced by depth of shade (fabric GSM 160- Yellow)

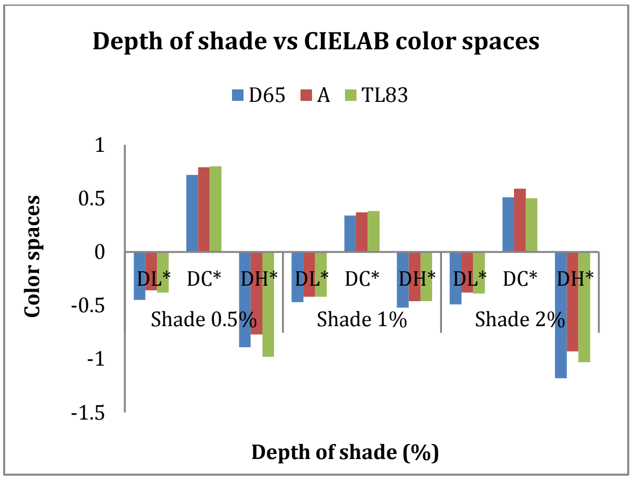

Fig. 10 CIELAB color spaces influenced by depth of shade (fabric GSM 180- Yellow)

From the above bar diagrams, figure 9 and 10 showed that CIELAB color spaces lightness, DL* was almost similar in all cases for specific GSM but this values were decreases as colorant concentration increases. Maximum saturation of dyes were found at lower concentration in case of higher GSM. The appendix (Table I) shows that the shade became more red and more yellow at lower dye concentration than higher one as well as higher GSM when fabric dyed with Reactobond Yellow 3RX 150%.

Conclusion

The combined response of three cone cells (response peaking at 440nm, 555nm and 585nm wavelengths respectively for Blue, Green and Red i.e variation of sensitivity with wavelength) provide the ability of distinguish luminosity and color. Color is nothing but a feature of visual perception dependent on the spectral composition of observed radiant energy. Color accomplished as a distinctive of a surface but its sensation varies from observer to observer, illuminant to illuminant. The results of our investigation allow us to suggest that the CIELAB color spaces ominously influenced by illuminant and dye concentration. The change of color spaces shows significant differences by viewing under different illuminants and dyed at various concentrations. As correlated color temperature varies from illuminant to illuminant the results indicates that dyed fabrics appears more darker at higher CCT (D65) and depth of shade. There may be due to more dye uptake occurs at higher concentration and thus gets less reflection which describes more absorption of dyes at higher GSM also.

References

Arthur D Broadbent (2001), Basic principles of Textile Coloration, *Society of Dyers and colourists*, 346-347.

V. A. Shenai (1993),Technology of Textile processing, *Sevak Publications, Bombay,* Vol-II, 557.

Deane B. Judd (1940), Hue, saturation and lightness of surface colors with chromatic illumination, *Journal of the Optical Society of America,* 30, 1-32.

Application note (2001), Hunter L,a,b Versus CIE 1976 L*a*b*, *The Color Management Company*, 13(2),1-4

Vimal K Sikri(2010), Color: Implications in dentistry, *Journal of Conservative Dentistry*, 13(4),249-255.

Raymond Davis (1930), A correlated color temperature for illuminants, *Bureau of Standards Journal of Research*, 7,659-681.

Linda Johansson (2004), Human colour vision,1-44

CIE Colorimetry - Part 2: Standard Illuminants for Colorimetry, retrieved (February 24,2015) from http://cie.co.at/index.php?i_ca_id=484

Md. Rahman, A.K.M. A.H. Asif, Md. A.B. Siddique, Md. Rokonuzzaman(2014), Effect of shade percentage on various properties of cotton knitted fabric dyed with reactive dyes, *International Journal of Research in Engineering and Technology*, Vol.3(2),.339-343.

A. N. M. A. Haque (2014), Influence of electrolyte and liquor ratio on exhaustion and color coordinates of cotton fabric dyed with mono-functional and bi-functional reactive dyes, *Borneo Science*, 34, 27-33.

A. N. M. A. Haque (2014), Influence alkali and temperature on fixation and color coordinates in dyeing with different reactive dyes, *International Journal of Scientific &Technology Research*, 3(5), 140-143.

Laszlo Tolvaj, Karoly Nemeth (2008), Correlation between Hue-angle and color lightness of steamed black locust wood, *Acta Silvatica & Lignaria Hungarica*,4,55-59.

Appendix

Table I CIELAB Color spaces For Dyed Fabrics (Reactobond Red 3BX 150% and Reactobond Yellow 3RX 150%)

Description			Reactobond Red 3BX 150%					Reactobond Yellow 3RX 150%				
Shade%	**Fabric GSM**	**Illuminant**	**DL***	**Da***	**Db***	**DC***	**DH***	**DL***	**Da***	**Db***	**DC***	
0.50%	120	D65										
		A	Standard									
		TL83										
	160	D65	-0.49	0.52	-0.32	0.22	-0.13	-0.34	0.97	0.26	0.19	-0.63
		A	-0.44	0.37	-0.22	0.14	-0.15	-0.3	1.11	0.35	0.23	-0.68
		TL83	-0.46	0.19	-0.38	0.08	-0.23	-0.31	1.33	0.49	0.27	-0.79
	180	D65	-0.83	1.68	0.26	0.64	0.29	-0.45	1.73	1.57	0.72	-0.89
		A	-0.68	1.41	0.78	0.59	0.41	-0.36	1.74	1.85	0.79	-0.77
		TL83	-0.7	1.12	0.59	0.46	0.35	-0.38	1.96	1.95	0.8	-0.98
1.00%	120	D65										
		A	Standard									
		TL83										
	160	D65	-0.38	0.5	0.47	0.18	0.26	-0.33	0.05	-0.11	-0.03	-0.06
		A	-0.3	0.47	0.65	0.22	0.32	-0.33	0.15	-0.16	-0.03	-0.13
		TL83	-0.32	0.23	0.6	0.12	0.34	-0.32	0.06	0.01	0.01	-0.04
	180	D65	-0.69	0.57	0.48	0.2	0.27	-0.47	1.06	0.70	0.34	-0.52
		A	-0.58	0.3	0.75	0.16	0.39	-0.42	1.05	0.86	0.37	-0.46
		TL83	-0.56	0.27	0.61	0.13	0.34	-0.42	1.04	0.95	0.38	-0.46
2.00%	120	D65										
		A	Standard									
		TL83										
	160	D65	-0.26	0.16	0.75	0.06	0.4	-0.3	-0.58	-0.27	-0.15	0.3
		A	-0.2	0.11	0.87	0.12	0.48	-0.32	-0.55	-0.41	-0.18	0.24
		TL83	-0.19	0.06	0.84	0.09	0.49	-0.31	-0.62	-0.45	-0.19	0.28
	180	D65	-0.22	1.09	2	0.42	1.05	-0.49	2.17	0.79	0.51	-1.18
		A	-0.07	1.26	2.49	0.58	1.26	-0.38	2.03	1.28	0.59	-0.93
		TL83	-0.06	1.25	2.26	0.48	1.25	-0.39	2.06	1.02	0.5	-1.03