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Transmittance behaviour of curtain fabrics under natural lighting conditions

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The light transmittance behaviour of four different coloured curtain fabrics has been studied under natural lighting conditions (morning, afternoon and evening). The intensity of incident sunlight and transmitted light from the samples are measured using Luxmeter, in an enclosed black chamber. The percentage of transmitted light is calculated with reference to the incident sunlight, to study the influence of colour and number of fabric layers. It is observed that the transmittance behaviour of curtain fabrics is highly influenced by its colour due to the spectrum of colours, which is followed by the influence of number of layers and sunlight conditions. Further, the transmittance % of curtain is also influenced by the wavelength of incident sunlight.

Keywords: Curtain fabric, Disperse dye, Dyeing, Transmittance behaviour, Polyester fabric

1 Introduction

Curtains are one of the important home textile products that have a vital role in household environment. Hence, the selection of suitable curtains with better light transmittance and reflectance behaviour are necessary for better interior. Light transmittance behaviour of curtains is influenced by its colour, structure, cover factor, number of fabric layers during its drape and the intensity of incident light. In a recent study, Chen *et al.*[1] analysed the effect of colour on the optical properties of disperse dyed tricot invisible warp-knitted curtain fabrics, through spectrophotometer. The results indicated that the fabrics dyed with different dyes have different optical properties; their optical transmittance and reflectance decrease after dyeing, which make transmittance and reflection performance worse. The dark purple, deep yellow and light yellow samples have better light-admitting and anti-peep performance than other samples. Similarly, the light transmission through decorative knitted fabrics in correlation with its fabric cover was studied by Szmyt and Mikolajczyk[2], using digital image analysis technique and digital camera. They found that the increase in fabric cover increases its light absorbency and decreases its transmittance. The curve of incident light with respect to fabric cover has a linear character. Further, it was observed that the transmitted light intensity increases with increase in incident light intensity.

Szmyt and Mikolajczyk[2] also studied the light barrier properties of decorative jacquard knitted fabrics, using experimental stand measuring tunnel setup. A light emitting diode matrix was used as the source of light, and high precise sensors and camera were used as the mode of measuring the transmittance and reflectance behaviour of samples. From the study, they found that the barrier properties of decorative knitted structures have a significant correlation with light transmission and reflection behaviour[3]. However, all the studies till date, related to transmittance behaviour of curtains, have been done under artificial lighting condition, but in real time application curtains are used to prevent the excessive transmission of natural sunlight. The transmittance behaviour of curtains is expected to change with the intensity and properties of incident light (natural or artificial light). Further, apart from curtain colour, structure and fabric cover, the number of layers which varies based on draping conditions also influence the optical behaviour of curtain fabrics[4]. Therefore, in this study the influence of curtain colour, number of layers and light intensity on transmittance behaviour has been studied under natural sunlight conditions, using a simple experimental setup.

2 Materials and Methods

2.1 Materials

Polyester warp knitted fabrics with 17 courses/cm, 14 wales/ cm and 1.5 mm loop length (ASTM D

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3887; AATCC, 2014) were used in the study. The curtain samples have mass per unit area of 182 g/m^2, with 252 denier ground and 282 denier face yarns (ASTM D 3776).

2.2Methods

The samples were dyed with four different colour disperse dyes using standard dyeing technique[5]. For the colour realizing of yarn-dyed fabric a novel method is proposed by Pan *et al.*[6] using flat scanner. Similar method has been adopted in this study. The colour image of dyed curtain samples was obtained by a flat scanner, and the RGB values of different coloured curtains were obtained. Figure 1 shows the different colour dyed samples, and Table 1 shows their respective RGB values.

To evaluate the transmittance behaviour of the fabric samples, an enclosed black chamber (Fig. 2) was used along with "Equinox High Intensity Lux Meter" (Model EQ 1308). Lux meter used in the study has the resolution of 0.1 lux/ Fc and accuracy of ±5 % at less than 10,000 Lux and ± 10% at greater than 10,000 Lux. The photo detector (sensor) of Luxmeter with 7 cm diameter is positioned at the middle of enclosed chamber to measure the intensity of incident and transmitted light. Hence, an equal opening size of 7 cm diameter is provided at the top of black chamber, for the passage of incident sunlight. Since black colour is known to have better absorbance of light and avoid scattering of light, the chamber is kept black coloured on the inner side, to avoid the reflection or stray light passing through the test specimen[7].

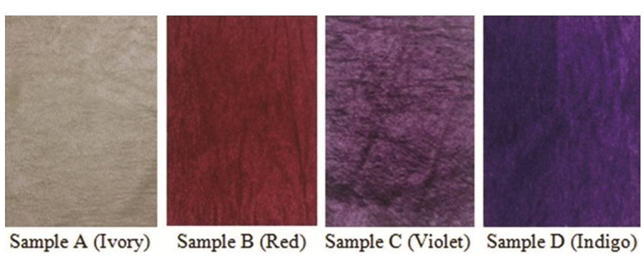

Fig. 1 — Curtains samples dyed with four different colours

Table 1 — RGB values of different coloured curtain samples

Sample	Colour	R	G	B
A	Ivory	255	255	211
B	Red	180	33	62
C	Violet	78	17	51
D	Indigo	100	54	116

Transmittance tests were carried out in natural sunlight conditions. Intensity of incident sunlight was measured without sample (31°23'43.5"N latitude; 75°32'16.5"E longitude; 29 &30th April 2015) at three different times of the day, i.e morning (9:00 am), afternoon (1:00 pm) and evening (5:00 pm). During the same time, the transmittance tests were carried out with samples by covering the top opening of the chamber. Sample of 8 cm length and 8 cm width was placed over the 7 cm opening of the chamber (Fig. 2). Since during the drape of curtains light passes through more number of layers, transmittance test was carried out with different fabric layers. To perform testing at increased number of layers, the face and backside of the samples was altered (Fig. 3) to simulate the real time draping conditions. Fifteen trials for each test were carried for each sample and layer combination, and the average transmitted light intensity was calculated. From the average intensity of incident light and transmitted light, light transmittance % was calculated as the ratio of amount of light transmitted through the fabric sample to the incident light falling on the sample, as shown below;

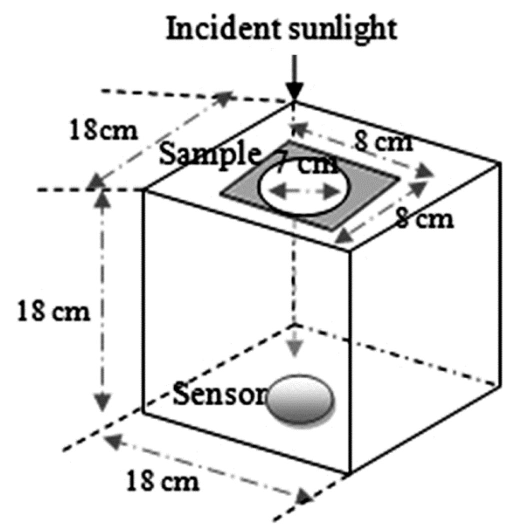

Fig. 2 — Experimental setup for light transmittance

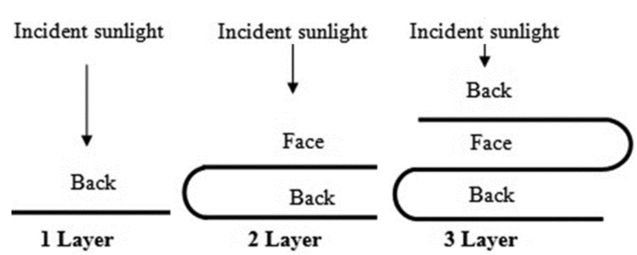

Fig. 3 — Arrangement of samples at increased number of layers

$$\text{Light transmittance \%} = \frac{I_t}{I_i} \times 100 \qquad \dots (1)$$

where I_t is the transmitted light intensity; and I_i, the incident sunlight intensity.

3 Results and Discussion

Table 2 shows the transmittance % of different fabric samples at different layers and sunlight conditions. It is observed that incident sunlight intensity is highest in the afternoon (1515 lux) and least in the morning (1330 lux). This is due to the scattering of light in the morning and evening sunlight. However, afternoon sunlight has the highest incident light intensity, but the light transmittance through the fabric samples is found to be highest in the evening, when incident light intensity is moderate. This is due to the longer wavelength of red spectrum (800 nm) in evening sunlight, which passes through the samples easily and results in higher transmittance % for all layers of ivory, violet and indigo coloured samples[8]. This observation is different from the past study[2] using artificial lighting conditions, where the transmittance percentage is observed to increase at increased artificial incident light intensity. Moreover, sample B (red) shows lower transmittance % in the morning and evening than in the afternoon, which may be due to its red colour. Although afternoon sunlight has the maximum intensity, the transmittance of evening sunlight is higher on clear day due to its higher wavelength, and such transmittance can be reduced by using red coloured curtains. Hence, it is preferable to use red tinted curtains at the west facing windows, where the incident evening sunlight would be prominent.

Among four different coloured samples, sample A with lighter ivory colour shows the highest light transmittance at all number of fabric layers and sunlight conditions (Figs 4 and 5), which is due to its highest RGB value. Higher the RGB

Table 2 —Light transmittance for different fabric samples

Sample	Time	Incident light lux	Intensity of light, lux			Transmittance, %		
			Layer 1	Layer 2	Layer 3	Layer 1	Layer 2	Layer 3
	Morning	1330.00	16.49	2.79	0.79	1.24	0.21	0.06
		(2.98)	(1.68)	(2.04)	(2.50)			
A (Ivory)	Afternoon	1515.00	387.00	95.80	37.40	25.54	6.32	2.46
		(2.18)	(1.54)	(1.47)	(1.84)			
	Evening	1348.00	366.00	103.00	33.68	27.15	7.64	2.49
		(2.46)	(1.58)	(1.96)	(2.29)			
	Morning	1301.00	8.71	0.26	0.13	0.67	0.02	0.01
		(3.12)	(1.53)	(1.90)	(2.90)			
B (Red)	Afternoon	1340.00	51.80	10.00	4.30	3.86	0.74	0.32
		(2.24)	(1.38)	(1.77)	(2.4)			
	Evening	1329.00	41.33	6.37	2.39	3.11	0.48	0.18
		(2.64)	(1.41)	(1.82)	(2.65)			
	Morning	1103.00	3.42	0.22	0.11	0.31	0.02	0.01
		(2.56)	(1.97)	(2.03)	(2.59)			
C (Violet)	Afternoon	1245.00	21.45	5.01	3.22	1.72	0.40	0.25
		(2.06)	(1.67)	(1.58)	(2.04)			
	Evening	1145.00	20.26	5.25	3.13	1.77	0.45	0.27
		(2.59)	(1.69)	(1.88)	(2.19)			
	Morning	1250.00	10.12	0.25	2.42	0.81	0.02	0.008
		(3.21)	(1.71)	(2.05)	(3.10)			
D (Indigo)	Afternoon	1279.00	53.80	6.86	3.15	4.20	0.53	0.24
		(2.44)	(1.48)	(1.85)	(2.58)			
	Evening	1255.00	54.21	7.02	3.73	4.32	0.55	0.29
		(2.51)	(1.68)	(1.90)	(2.61)			

Values in parentheses are standard deviations.

value, lighter is the shade and lower is the absorbance by the fabric, which facilitates better transmission of light[9]. On the other hand, RGB value of sample C (violet) is lowest, and therefore it absorbs highest amount of light and shows the lowest value of light transmittance (Fig. 5). Samples B (red) and sample D (indigo) with moderate RGB values show moderate transmittance values at different number of fabric layers and sunlight conditions (Table 2). Lighter fabric samples (having higher RGB values) show a significant increase in light transmittance in the afternoon and evening. Light transmittance increases from 1.24% to 27.15% for single layered fabric sample A (ivory). The darker colours follow the similar trend but with little increase in transmittance % (Table 2). Analysis of variance shows a significant interaction between the colour and the lighting intensity, with a contribution of 17.20%.

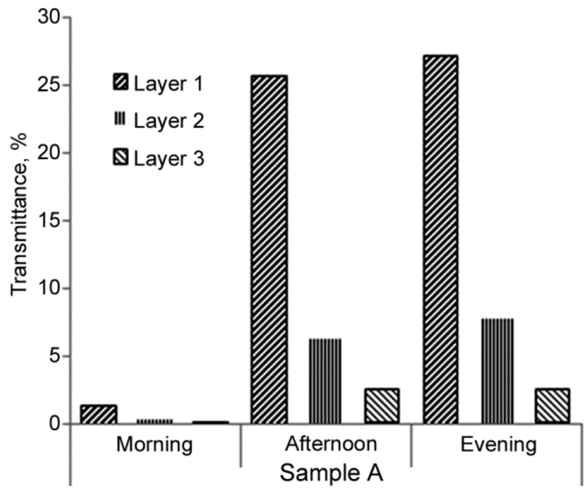

Fig. 4 — Transmittance % of sample A at different sunlight conditions and number of layers

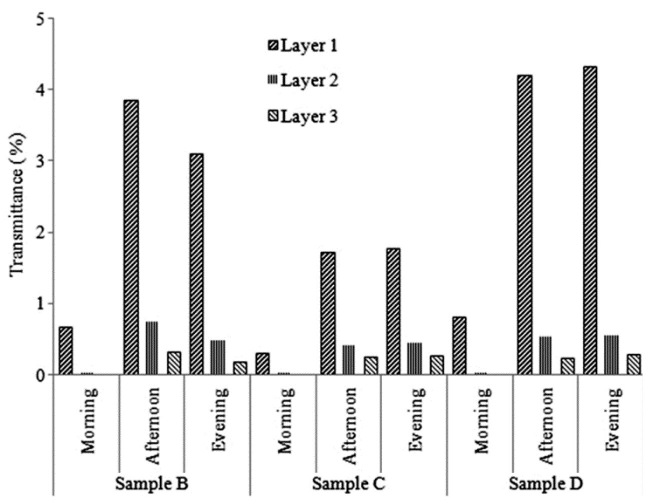

Fig. 5 — Transmittance % of samples B, C and D at different sunlight conditions and number of layers

With increased number of layers from single to double layers, all fabric samples show significant reduction in light transmittance % (Figs 4 and 5). This is due to the decreased fabric porosity **%**. The light absorbency of fabric is known to increase at lower porosity %, which results in the reduction of transmittance % (ref. 4). Moreover, Beer-Lambert law states that the light absorbency of material is directly proportional to the path length and density of the material through which the light travels[10]. The path length travelled by the light increases as the number of fabric layers increases and therefore light transmittance % decreases. However, increase in number of layers from 2 to 3 shows a marginal decrease in transmittance % for all fabric samples. This is due to the significant reduction in the light intensity after the first two layers.

From the ANOVA analysis of transmittance % (Table 3), it is observed that sample colour, number of layers and lighting conditions have significant influence on transmittance % with contribution of 27.59, 16.17 and 7.24 % respectively.

Table 3 —ANOVA analysis of transmittance

Effect	Sum of square	Degree of freedom	Mean square	F	P	Contribution, %
Intercept	263.1622	1	263.1622	26.0317	0.0002	-
Fabric colour	354.5626	3	118.1875	11.6909	0.0007	27.59
No of layers	210.2487	2	105.1243	10.3987	0.0023	16.17
Sunlight conditions	105.4014	2	52.7007	5.2130	0.0234	7.24
Colour*sunlight conditions	262.7906	6	43.7984	4.3324	0.0148	17.20
Colour*No. of layers	164.1002	6	27.3500	2.7054	0.0671	8.80
No. of layers* sunlight conditions	78.0563	4	17.222027	1.9303	0.1699	3.20
Error	121.3116	12	10.1093			

4 Conclusion

In this study, transmittance behaviour of four different coloured curtain fabrics is studied at natural sunlight conditions, by varying the number of layers based on draping conditions. It is observed that the transmittance behaviour of curtain fabrics varies with the sunlight conditions. Although incident light intensity is highest in the afternoon but the transmittance % is found to be highest in the evening for all samples, except sample B (red coloured), which is due to the higher wavelength of evening sunlight. This observation is found different from the past study using artificial lighting conditions, where the transmittance percentage is observed to increase at increased artificial incident light intensity. Further, sample B (red) shows lower transmittance % in the morning and evening sunlight, as compared to that in afternoon sunlight, due to its red colour. Also it is observed that the light transmittance % decreases at increased number of fabric layers, due to higher fabric cover.

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References

1 Chen W L, Zhu J X & Tang Z B, *Adv Material Res*, 391 (2012) 515.
2 Szmyt J & Mikolajczyk Z, *Autex Res J*, 10 (2010) 44.
3 Szmyt J & Mikolajczyk Z, *Fiber Text* East Eur, 2 (2013) 104.
4 Parmar M S, Sisodia Nidhi & Singh Maheshwar, *Indian J Fibre Text Res*, 40 (2015) 231.
5 Chakraborty J N, *Fundamentals and Practices in Coloration of Textiles* (Woodhead Publishing Limited, Cambridge), 2014, 209.
6 Pan R, Gao W & Liu J, *Proceedings, World Congress on Software Engineering* (CNC press, Xiamen, China), 2009, 1.
7 Thomas B B, *Light- It's Interaction with Art and Antiquitie* (Plenum Press: New York), 1980, 87.
8 *Intro to Spectrophotometry*, 2016. http://employees.oneonta.edu/kotzjc/LAB/Spec_intro.pdf.
9 Grosicki Z J, *Elements of Colour; Watson's Textile Design and Colour: Elementary Weaves and Figured Fabrics* (Woodhead Publishing Limited, Cambridge), 2004, 130.
10 Robinson J W, *Atomic Spectroscopy* (Marcel Dekker Inc, New York), 1996, 27.