Colorimetric properties of direct dyed cotton fabrics after treatment with softeners

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ABSTRACT

In this research, cotton fabrics were first scoured with nonionic detergent and then dyed with four direct dyes with different basic structures (Thiazole, Disazo, Trisazo and Polyazo). The dyed fabrics were then treated with anionic, cationic, nonionic, micro and macro silicone softeners. CIELAB color coordinates (L^*, a^*, b^*, C^* and h) were measured with reflectance spectrophotometer. The lightness (L^* value) for samples dyed with disazo and polyazo direct dyes (orange and red dyes) showed an increase after treatment with all the mentioned softeners, while it was decreased for thiazole and trisazo dyed fabrics treated with anionic, cationic, micro and macro silicone softeners and increased for fabrics treated with nonionic softener. The redness (a^*) for thiazole and disazo dyed samples (yellow and black dyes) decreased but it was increased for trisazo and polyazo dyed samples. C^* value for samples dyed with disazo, trisazo and polyazo direct dyes increased and they became brighter after treatment with softeners.

1. INTRODUCTION

Cotton is the major textile fiber and for many centuries it has found use in textile production.[1] Color plays a significant role in the use of cotton fibers.[2] Direct dyes are widely used to dye cotton for over 100 years.[2-5]

Softeners are usually used to change some of textile properties and they often have a multifunctional nature. They improve abrasion and soiling resistance, crease recovery, static protection, increase tearing strength and stretch, reduce pilling, color fastness, moisture absorbency, flammability, sewing thread breakage and needle cutting when the garment is sewn.[6-8] They are classified according to their ionic character and the main classes are: anionic, cationic, nonionic, amphoteric, reactive and silicone.[6] Softeners can affect the shade of dyed textiles. Some of them such as silicones will cause the shade to become darker. The reason for this is an optical phenomenon quantified by Fresnel: with decreasing refractive index of a medium the proportion of reflected light decreases (while more light is absorbed).[9]

High or low pH conditions in softening bath may cause changes in the electron configuration (resonance) of the dye molecules, the absorption shifts to a longer or shorter wavelength and it contributes to a change in color of dyed textiles.[10, 11]

Another problem, which appears in the use of softeners, is the tendency to develop a yellowish color when aged or heated especially in white fabrics. Some phenolic compounds are used particularly as antioxidants in softener solutions and they cause a reaction in the presence of nitrogen oxides, which are found increasingly in the atmosphere because of air pollution, this leads to the undesired yellowing effect.[12]

The work focuses on the changes in L^*, a^*, b^*, C^* and h of the direct dyed cotton fabrics occurring after treatment with softeners.

2. METHOD

MATERIALS

Twill weaves cotton fabric with warp and weft yarn count of 15 and 19 metric, and linear density of 35 cm^{-1}. Nonionic detergent (SDL Technologies) for scouring of cotton fabrics. Sodium chloride (Merck, Darmstadt, Germany) for dyeing processes. Levegal RDL (Bayer AG, Germany) used as leveling agent for dyeing processes. Direct dyes used along with their properties, are listed in Table 1. Softeners used along with their properties, are listed in Table 2.

Table 1: Direct dyes used in this study

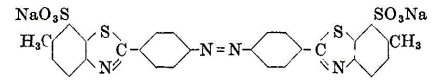
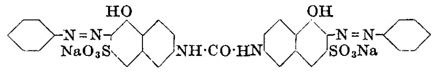
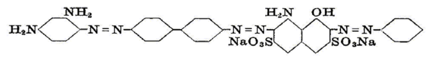
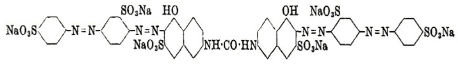
Dye	Commercial name	Chemical type	Chemical structure	CI constituents
1	Solar yellow BG	Thiazole		C.I.Direct yellow 28
2	Direct orange S	Disazo		C.I.Direct orange 26
3	Direct black EX	Trisazo		C.I.Direct black 38
4	Solar brilliant red BA	Polyazo		C.I.Direct red 80

Table 2: Softeners used in this study

softener	Commercial name	Chemical type	Supplier	pH of treatment
1	Rucolub KPM	Nonionic	Rudolf Chemie	7
2	Persoftal L	Anionic	Bayer AG	7
3	Persoftal UK	Cationic	Bayer AG	4-5
4	Persoftal ASN	Macro silicone	Bayer AG	5-6
5	Roma silicone 279	Micro silicone	Rotta Group	4-5

PROCEDURES

Cotton fabrics were scoured with 1% nonionic detergent. The L:G (liquor to good ratio) of the scouring bath was kept at 40:1 for 30 min at 50ºC. Dyeing solutions were prepared by adding direct dyes (2% owf), leveling agent (1% w/w) and salt (20 gr/lit). The initial pH of the dyebath was 7. The dyeing process was started at 40ºC and the temperature raised to 85ºC over 20 min and then held at that temperature for 1 h. Treatment with softener solution was carried out after dividing the dyed fabrics into seven parts. Two parts were retained untreated for reference and acid treatment, and the others were each treated with softener solutions (20 gr/lit) at 50ºC for 10 min and a liquor ratio of 10:1. The initial pH of solutions depended on the softener used as recommended by the respective manufacturers (Table 2). The treated fabrics were then dried at 140ºC for 3 min. One part of dyed samples was left in contact with acetic acid solution at pH 4-5 at 50ºC for 10 min and liquor ratio 20:1. To investigate the effect of softener on the dyed samples, the reflectance spectra were measured before and after treatment using an ACS Spectro-sensor II integrated with an IBM personal computer. CIELAB color coordinates (L^*, a^*, b^*, C^* and h) were calculated from the reflectance data for 10º observer and illuminant D65.

3. RESULTS

The L^*, a^*, b^*, C^* and h values of fabrics dyed with the four direct dyes used in this study, and those after-treated with softener solutions, are given in Table 3.

One of the dyes (dye 1) studied had a thiazole structure. It can be seen in Table 3 that the amount of L^* (=74.31) decreased to 73.51, 73.11 and 72.31, respectively, after the yellow dyed samples were treated with cationic, macro and micro silicone softeners, and it was increased to 76.06 for nonionic softener treated sample. There was no change in L^* value for anionic softener. This behavior could be due to higher refractive index of nonionic softener solution as compared to others, it reflects more light and so the nonionic softener treated sample appears a lighter shade. The *a** values for all treated samples decreased after treatment with softeners. The chroma (*C**) values for nonionic, anionic, cationic and micro silicone treated samples decreased after treatment with softeners, the shade becoming duller and dirtier, whereas fabric treated with macro silicone softener became brighter. Macro silicone softener treated sample showed more increase in yellowness as compared to other softeners and it may contents phenolic compounds as antioxidants or amine groups, which leads to yellowing tendency. To investigate effects of pH of softener treatment on dyed samples, treatment with acetic acid solution was carried out on samples. Table 4 shows color coordinates of acidified dyed cotton samples. The color of the cotton fabric dyed with yellow dyestuff was little changed in acid solution and the color coordinates being close to those for the original dyed sample. Acidic pH caused only a slight alteration to the color of this sample and color changes depend on the chemical type of softeners used.

Table 3: Color coordinates for dyed fabric, with and without softener treatment

Dye	Softener	L^*	a^*	b^*	C^*	h^o
1	Non-treated	74.31	13.01	73.37	74.52	79.95
	1	76.06	9.40	71.27	71.89	82.48
	2	74.31	12.03	72.53	73.53	80.58
	3	73.51	10.80	73.24	74.03	81.60
	4	73.11	11.78	75.37	76.29	81.11
	5	72.31	10.84	73.53	74.32	81.61
2	Non-treated	52.29	57.70	54.86	79.61	43.55
	1	58.30	53.42	66.52	85.32	51.23
	2	52.89	57.33	56.38	80.41	44.52
	3	55.67	54.42	63.24	83.43	49.28
	4	55.30	54.35	70.57	89.07	52.39
	5	53.82	54.38	65.35	85.02	50.23
3	Non-treated	18.99	-1.40	-2.30	2.69	238.75
	1	21.25	-2.17	-2.97	3.68	233.79
	2	18.42	-1.91	-3.40	3.90	240.61
	3	18.18	-1.65	-3.60	3.96	245.4
	4	14.80	-2.57	-2.86	3.85	228.09
	5	15.42	-2.10	-2.16	3.01	225.47
4	Non-treated	43.14	54.65	12.84	56.14	13.22
	1	47.39	57.74	21.46	61.60	20.39
	2	45.41	56.57	15.76	58.72	15.56
	3	45.73	57.66	19.73	60.94	18.88
	4	44.59	58.37	23.57	62.95	21.99
	5	43.93	56.64	18.95	59.73	18.50

Table 4: Color coordinates of acidified dyed cotton samples

Dye	L^*	a^*	b^*	C^*	h^o
1	74.31	13.01	73.37	74.52	79.95
2	76.06	9.40	71.27	71.89	82.48
3	74.31	12.03	72.53	73.53	80.58
4	73.51	10.80	73.24	74.03	81.60

Table 3 also shows color coordinates for cotton dyed with disazo dye 2 (Direct orange S), both untreated and treated with anionic, cationic, nonionic, micro and macro silicone softener solutions. It can be seen from Table 3, however, that fabric dyed with dye 2 showed some increase in

*L**, *b** and *C** values, and decrease in redness after treatment with softeners, the shade becoming lighter and brighter. Treatment with anionic softener caused only a slight alteration in this color, as is confirmed by the relatively small change in *L**, *a** and *C** values. Nonionic and macro silicone softeners increased the *L** and *b** values for orange dyed sample similar to the behavior of yellow dyed one.

Direct black EX (dye 3) have a trisazo structure, and the color coordinates are shown in Table 3. It can be seen in Table 3 that *L** value for dye 3 decreased after treatment with all softeners but nonionic softener showed an increase. Macro and micro silicone softeners showed more decrease in lightness as compared to other softeners, so they can be used as deeping agents in deep shades.

Finally, the color coordinates for dye 4, having a polyazo structure, are shown in Table 3. The *L**, *a**, *b** and *C** values showed an increase after treatment with softeners and the shade became lighter and brighter. The increase in *L** and *b** values for dye 4 is similar to the behavior of dye 2 after treatment with softeners.

4. CONCLUSIONS

On treatment with nonionic softener solution, cotton fabric dyed with a range of direct dyes showed an increase in *L** value in every instance. This behavior could be due to higher refractive index of nonionic softener solution as compared to others. Anionic softener caused only a slight alteration on the color of dyed fabrics except for dye 4 as can be seen in Table 3. The *b** values for all the dyed samples were increased on treatment with macro silicone softener. This softener may contents antioxidants or amine groups which leads to yellowing tendency. Treatment with softeners was found to increase the *C** value of the dyed samples and they became brighter but all the softeners except macro silicone caused the shade of dye 1 to become duller and dirtier. Acidic pH caused only a slight alteration to the color of all samples, while the color changes depend on the chemical type of softeners used. Macro and micro silicone softeners showed more decrease in lightness of dye 3 (black color) as compared to other softeners and they can be used as deeping agents in deep shades.

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