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BEHAVIOUR OF IR REFLECTIVE DYES AND PIGMENTS ON DIFFERENT FATLIQUORED UPHOLSTERY LEATHERS

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Abstract: *IR Reflective dyes and pigments are designed to make absorption in the visible region of the electromagnetic spectrum like the standard dyes but to reflect the Infra-Red region of the spectrum as a difference; which enables the items dyed with them to heat less for darker shades when exposed to sunlight. In this study, a standard acid dyestuff and an IR reflecting acid dyestuff are used on leathers produced with 4 different fatliquoring processes. They are finished with standard and IR reflective pigments respectively. Then reflection behaviors of the resulting leathers were measured with an IR spectrophotometer to visualize the working theory. Later, the fastness properties of leathers were tested to see if they are applicable to leather articles and resistant to wear. Spectrums showed that black IR reflective dyes and pigments stop absorbing and start reflecting light with wavelengths above 700 nm which results cooler leathers under solar radiation. Rubbing fastness results showed that leathers, treated with IR reflective dyes and pigments, had better results with a slight difference than other standard acid dyestuff groups, which proved the durability of this application during wearing. When different fatliquoring processes were compared, it was not seen significant differences in final colors, reflection properties, and rubbing fastness results.*

Keywords: *Leather, IR Reflective, Dyes, Dyestuff, Pigments*

1. INTRODUCTION

The transformation of animal skin into leather is a complex process encompassing several steps, among which leather dyeing adds value to the material for market purposes [1,2]. The process of dyeing in the leather making is carried out to impart color and esthetics to tanned hides and skins. The behavior of dyes is primarily determined by the charge characteristics of both the dye and the leather to be dyed [3,4]. Black dyes and pigments occupy a pivotal position with the growing global demand in the textile, cosmetic, paper, and printing industries. Black-colored products absorb all the sun radiation including near IR and cause a heating problem. This results comfort problems for customers using black dyed leather items like motorcycle seats, motorcycle clothing, automobile steering wheels, seats, and sometimes black shoes. So reflecting the solar radiation in the infrared area of the radiation spectrum higher than 700 nm is a solution for the heating problem without affecting the visible color. For this reason, IR reflective dyes and pigments are designed [5]. Another important process of leather production is fatliquoring, which is done to give softness, elasticity, handle properties, and fullness to the leathers. The Fatliquoring process also affects physical and mechanical properties [6], such as strength, elongation, water absorption, water vapor permeability, gas permeability [7,8,9], thermal properties, and light fastness properties depending on the fatliquor type and amount used. The leather industry uses different kinds of fatliquors including either untreated or emulsified oils, fats and fatty alcohols, paraffin waxes, mineral oils, olefins, processed hydrocarbons, sulfated and sulfochlorinated products [10,11]. In our previous study, it was found that waterproofing fatliquors decreased the moisture content and water absorption properties of leathers and resulted less heating of the leathers [5]. In this study; reflectance spectrums, rubbing, and light fastness properties of IR reflective dyes and pigments on leathers fatliquored with natural, synthetic, and waterproof fatliquors are investigated comparing with a standard dyeing and finishing process.

2. EXPERIMENTAL

2.1 Material

4 groups of leather samples, fatliquored with different fatliquoring materials as shown in Table 1, were used as material. These samples were divided into 4 pieces and 2 of them were dyed with standard dye and the other 2 samples were dyed with IR reflecting dyes. The IR reflecting dyes & pigments, the mixture of natural and synthetic fatliquors, and waterproofing fatliquors were products of TFL Turkey. Natural and synthetic fatliquors were products of Zschimmer & Schwarz. The leather samples dyed with standard acid dyestuff dye were finished with a standard upholstery finishing recipe while the IR reflective dyed samples were finished by using IR reflective pigments [5]. The experimental design can be seen in Table 1.

Table 1. *Experimental Design*

Fatliquoring system	A - Standard Dyed Leather	B - IR Reflecting & Pigments Dyed Leather
1- Combination of Selected Natural and Synthetic Fatty Substances (Lecithin)	1A	1B
2- Synthetic Fatliquoring Agent	2A	2B
3- Natural Fatliquoring Agents	3A	3B
4- A Waterproof Fatliquoring System	4A	4B

2.2 Method

Hunterlab UltraScan Pro color measurement spectrophotometer was used to measure spectral reflectance of leather samples between the wavelengths of 350-1050 nm, which includes near UV, visible, and near IR region of the electromagnetic spectrum.

Lightfastness tests of the leather samples were performed by using the Atlas Xenotest Alpha+ test instrument by using the test standard ISO 105-B02 (2014) [12]. Samples were exposed to artificial light under controlled conditions, together with a set of blue wool fabric test reference materials (no.1 to no.8). The color fastness is assessed by comparing the color change of the exposed and the unexposed regions of the test specimen when the test reference no.4 faded to grade 4 of the grayscale.

The CIE L*, a*, b* color coordinates of the samples were measured by using CM3600d Konica Minolta spectrophotometer with the respective parameters of D65 illuminant, wavelengths range of 360-740 nm, 5 mm diameter of measuring space, and 10° light incident angle. Color measurements were repeated after the light fastness test on the light-exposed areas of samples. The color differences of leathers before and after the light fastness test were calculated according to the CIE Lab-76 color difference formula [13].

Colorfastness is of critical importance while caring for the apparel. Color is vulnerable to changes due to abrasion, exposure to heat and light, laundering, and perspiration [14,15]. Bally Finish Tester was used to test colorfastness to cycles of to–and–fro rubbing of the leather samples in dry, wet, and perspiration conditions by using standard felts according to test standard TS EN ISO 11640 (2013) [16]. The leather samples and the test felts were evaluated by using grayscales mentioned in the standards 423-2 EN 20105-A02 (1996) and TS EN ISO 105-A03 (2019) respectively [17,18].

3. RESULTS AND DISCUSSIONS

The visible light perceived by humans ranges from wavelengths of approximately 380–750 nm [19]. Absolute thresholds vary from person to person and according to viewing conditions. Wavelengths from approximately 10–380 nm are termed ultraviolet. The IR portion of the spectrum ranges from approximately 750 nm–1 mm, with near-infrared (NIR) ranging from 750–1400 nm [19]. Objects exposed to NIR radiation (such as from an alternate light source) absorb, reflect and transmit these photons to varying degrees [20]. The solar energy from the near-IR and IR region of the solar spectrum are responsible for the heat build-up of dark-colored leather articles [21].

The graphics of spectral reflectance of leather samples with standard and IR reflective dyeing applications are shown in **Fig.1-4**. The spectral reflectance data on different wavelengths of samples are shown in Table 2. It is seen that the leathers dyed with standard acid dyestuff made absorption at all wavelengths; while leathers with IR reflecting dyes & pigments made absorption only at the visible region and made reflection at the IR region of the spectrum. This behavior was the same for all leather samples which had 4 different fatliquoring processes.

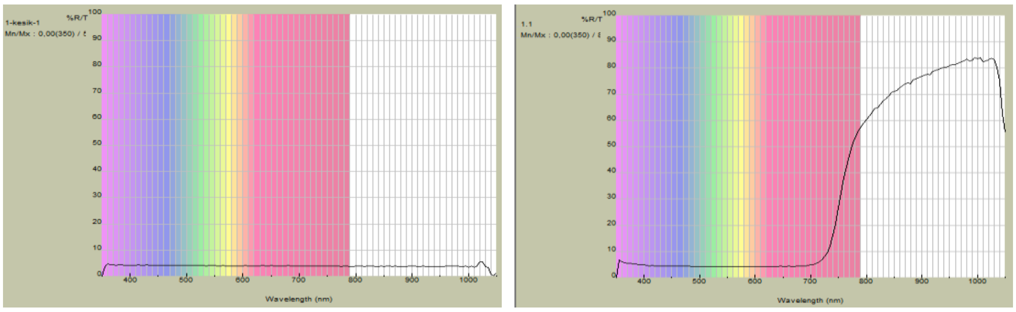

Fig. 1. *Spectral reflectances of 1A and 1B*

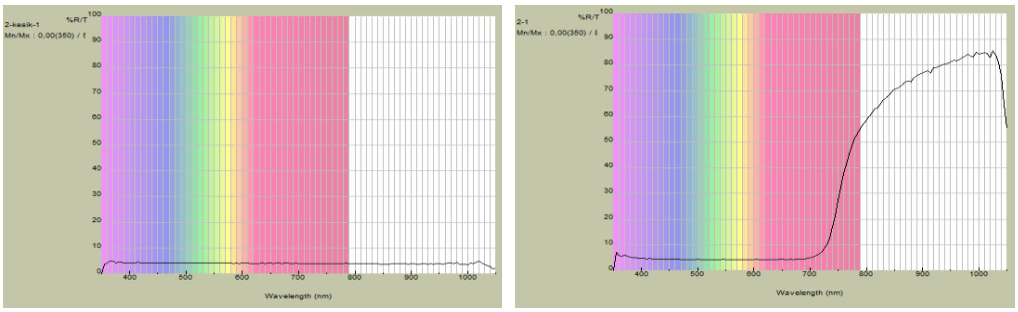

Fig. 2. *Spectral reflectances of 2A and 2B*

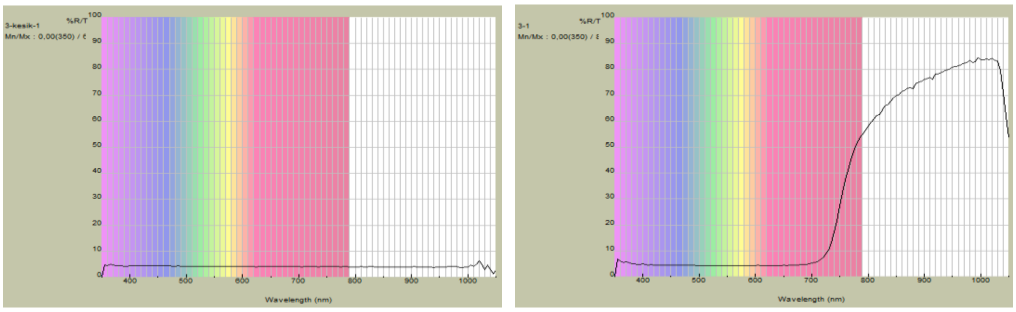

Fig. 3. *Spectral reflectances of 3A and 3B*

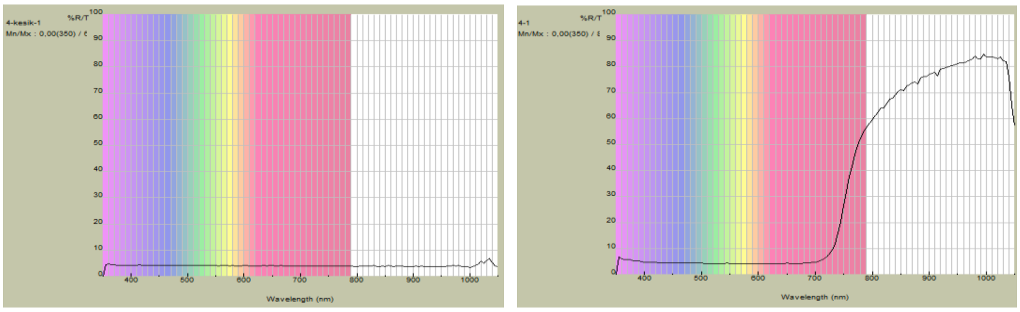

Fig. 4. *Spectral reflectances of 4A and 4B*

Table 2. *Means of Spectral reflectance data of leather samples in different wavelengths*

	Wavelength (nm)					
	500	700	750	800	900	1000
Group A	4.23	4.06	4.01	3.88	3.91	3.52
Group B	4.35	4.92	26.78	59.65	77.02	84.01

Rubbing fastness (dry, wet, perspiration) test results of leather samples with standard acid dyestuff and IR reflecting dyes & pigments are given in Tables 3 and 4. When two tables were compared, rubbing fastness results showed that leathers, treated with IR reflective dyes and pigments had slightly better results.

Table 3. *Rubbing fastness test results of leathers with standard dyes*

	Leather			Felt		
	Dry	Wet	Perspiration	Dry	Wet	Perspiration
1A	5	5	5	4/5	4	3/4
2A	5	5	5	4/5	4/5	4
3A	5	5	5	5	4/5	4
4A	5	5	5	4/5	4	3/4

Table 4. *Rubbing fastness test results of leathers with IR reflecting dyes & pigments*

	Leather			Felt		
	Dry	Wet	Perspiration	Dry	Wet	Perspiration
1B	5	5	5	5	4/5	4
2B	5	5	5	5	4/5	4
3B	5	5	5	5	4/5	4
4B	5	5	5	5	4/5	4

Lightfastness results of leather samples with standard and IR reflecting dyes & pigments were given in Tables 5 and 6. On a typical scale, the Delta E value can range from 0 to 100. When the Delta

E value is between 0 and 1, the observer does not notice the difference [22]. All Delta E values of samples were found lower than 0.5 which we can conclude that both of dying systems have good lightfastness properties and the different fatliquoring materials used in the study had no negative effect on lightfastness.

Table 5. *Lightfastness test results of leathers with standard dyes*

	Before			After			∆E
	L	a	b	L	a	b	
1A	24.699	0.234	-0.554	24.815	0.295	-0.650	**0.163**
2A	24.826	0.166	-0.566	24.965	0.228	-0.648	**0.172**
3A	24.693	0.175	-0.530	24.745	0.245	-0.643	**0.143**
4A	24.665	0.198	-0.528	24.835	0.273	-0.620	**0.208**

Table 6. *Lightfastness test results of leathers with IR reflecting dyes & pigments*

	Before			After			∆E
	L	a	b	L	a	b	
1B	24.334	-0.030	-0.785	24.590	-0.025	-0.783	**0.256**
2B	24.503	-0.025	-0.791	24.543	0.020	-0.713	**0.088**
3B	24.165	-0.048	-0.725	24.473	-0.058	-0.708	**0.085**
4B	24.166	-0.053	-0.711	24.175	-0.010	-0.678	**0.037**

4. CONCLUSION

IR reflecting dyes and pigments can be used to make absorbance in the visible region of the light spectrum while making reflection in the near IR region. This provides less heating for darker shades for leather articles and so provides thermal comfort for users. In this study, this working theory of IR reflecting dyes & pigments was demonstrated with spectral reflectance graphics and spectral data of the samples.

Additionally, the fatliquoring technology which affects moisture content and thermal properties of leathers, thus the heating of samples was investigated. It was found that the experimented fatliquors do not affect either reflectance values or the fastness properties.

The dry, wet, and perspiration rubbing and lightfastness test results show that IR reflecting dye and finishing application does not have any negative effect on performance values, on the contrary, has slightly better results, and can be applied without affecting the rubbing and light fastness properties of leather items.

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