



OPTICAL WHITENING OF 50/50% PES/WOOL FABRICS

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Abstract: *If a high level of whiteness is required for wool and wool blends, it is normal to carry out a combined oxidative/reductive bleaching treatments. A higher whiteness can be achieved by the use of optical whitening agents. The aim of this experimental work was to whiten 50/50% PES/Wo woven fabrics. 50/50% PES/Wool fabrics were first bleached in acidic conditions by hydrogen peroxide, and then, the reduction washing processes were carried out by sodium hydrosulphite (Merck), thiourea dioxide (Merck) or sodium borohydride (DyStar). The optical whitening agents, Hostalux ETB Liq. and Leucophor BSB Liq. were later applied at four different concentrations either in a single bath or in two separate baths to the fabrics treated with one of these three chemicals. The processes were repeated twice to check the repeatability of the results. The optical whitening processes were carried out in a laboratory type HT machine (Roaches). The colour measurements were carried out by Datacolor SF600+ spectrophotometer. The Whiteness Indexes of the optically whitened samples were evaluated in accordance with CIE Whiteness Index. The optical whitening agent used for wool gave better results, and also the best results were obtained in single-bath treatments. The best whiteness value was obtained with hydrogen peroxide bleached and washed with sodium hydrosulphide samples which were later optically whitened with 0.8% Hostalux ETB Liq. and 2% Leucophor BSB Liq. at 95°C treatment.*

Key words: *optically whitening, 50/50% polyester/wool blends, reductive washing*

1. INTRODUCTION

The whitening of 50/50% PES/wool blends is a difficult task[1-3]. Oxidative (based on stabilised hydrogen peroxide), reductive (based on thiourea dioxide or hydrosulphite) or combined oxidative/reductive are commonly used in exhaust bleaching processes for wool. Where a high level of whiteness is required, it is normal to carry out combined oxidative/reductive bleaching treatments[4-7]. In this work, 50/50% PES/Wo woven fabrics was optically whitened using different methods. 50/50% PES/Wo fabrics were first bleached in acidic conditions by hydrogen peroxide, and then, the reduction washing processes were carried out by sodium hydrosulphite (Merck), thiourea dioxide (Merck) or sodium borohydride (DyStar). The optical whitening agents, Hostalux ETB Liq. [8] and Leucophor BSB Liq. [9] were later applied at four different concentrations either in a single bath or in two separate baths to the fabrics treated with one of these three chemicals. The colour measurements were carried out by Datacolor SF600+ spectrophotometer. The Whiteness Indexes of the optically whitened samples were evaluated in accordance with CIE Whiteness Index.



2. EXPERIMENTAL

50/50% PES/Wool (293 g/m²) woven fabric was used throughout this experimental work. In the processes, hydrogen peroxide (Merck), Peristal EJP (Dr. Petry), Imerol JW TR Liq. (Clariant), hydrosulphite (Merck), thiourea dioxide (Merck), Sera Con C-BOR (DyStar), Sera Con C-RAP (DyStar), Hostalux ETB Liq. (Clariant), Leucophor BSB Liq. (Clariant), Dilatin POE (Clariant) and acetic acid were used. Roaches HT Sample Dyeing Machine was used in the treatments. The spectral measurements of the samples were carried out by Datacolor SF600+ spectrophotometer, and the CIE WI values were calculated using Datamatch software with 10° Standard Observer and D65 illuminant.

In the bleaching treatment, 40 mL/L H₂O₂ (%35), 2 mL/L Peristal EPJ and 1 mL/L Imerol JW TR were used. The liquor ratio was 20:1. The process was carried out at pH 5.5-6.5 and at a temperature of 60-80°C for 1 hour. Then, a hot and a cold rinses were given to the material. The process conditions of the reductive washings were given in Table 1. The fabrics were eventually rinsed by hot and cold water.

Table 1: Process conditions of the reductive washings of the materials.

Chemicals Used	Amount Used		
	Reductive washing by sodium hydrosulphite	Reductive washing by thiourea dioxide	Reductive washing by sodium borohydride
Hydrosulphite	4 g/L	-	-
Thiourea dioxide	-	0.5 g/L	-
Sera Con C-BOR	-	-	3 g/L
Sera Con C-RAP	-	-	30 g/L
Imerol JW TR	1 g/L	-	1 g/L
pH	-	5- 5.5	-
Temperature (°C)	50	80	85
Time (min.)	40	10	20

The conditions of the optical whitening processes were given in Table 2. After each process, the fabric was given a hot and cold rinses, respectively.

Table 2: Optical whitening processes.

Chemicals Used & Process Conditions	The process in which PES and Wool optically whitened in a single bath	The process in which PES and Wo optically whitened in two separate baths	
		Amount used	
	Amount used	Step 1: Optically whitening of PES	Step 2: Optically whitening of Wool
Hostalux ETB Liq.	0.2%, 0.4%, 0.6% and 0.8%	0.2%, 0.4%, 0.6% and 0.8%	-
Leucophor BSB Liq.	0.5%, 1%, 1.5% and 2%	-	0.5%, 1%, 1.5% and 2%
Dilatin POE	2%	2%	-
Hydrosulphite	-	-	3 g/L
Imerol JW TR	-	-	0.5 mL/L
pH	4.5- 5.5	4.5- 5.5	4.5-5.5
Temperature (°C)	95 or 110	110	70
Time (min.)	30	40	60
Liquor Ratio	1:10	1:10	1:10



3. RESULTS AND DISCUSSIONS

The CIE Whiteness Indexes of the untreated and the reductive washed samples were given in Table 3. As seen in Table 3, the CIE Whiteness Index of the untreated sample is very low, CIE WI 14.6. After bleaching the fabric with hydrogen peroxide, and later reductive washing the samples with sodium hydrosulphite, sodium thiourea dioxide or sodium borohydride slightly changed the whiteness values only.

Table 3: The Whiteness Indexes of the oxidative bleached and later reductive washed samples.

Sample	CIE Whiteness				
	WI	T _w	x	y	Y
Untreated	14.6	-4.8	0.34	0.35	68.7
Bleached and reductive washed with sodium hydrosulphite	48.1	-0.1	0.32	0.34	73.0
Bleached and reductive washed with sodium thiourea dioxide	34.0	-4.5	0.33	0.35	73.4
Bleached and reductive washed with sodium borohydride	30.9	-6.1	0.33	0.35	70.1

The Whiteness Indexes of the samples which were bleached, treated with reductive clearing agents and also with optically whitening agents were given in Table 4 and Table 5.

Table 4: The Whiteness Indexes of the samples which were bleached, treated with reductive clearing agents and also with optically whitening agents.

Reductive washing	Process	Applied concentration	CIE Whiteness				
			WI	T _w	x	y	Y
Reductive washed with hydrosulphite	Processed with optically whitening agent for PES	% 0.2 H	65.5	-2.1	0.32	0.33	69.2
		% 0.4 H	76.2	-2.8	0.31	0.33	68.9
		% 0.6 H	82.8	-2.4	0.31	0.32	69.6
		% 0.8 H	85.2	-1.1	0.31	0.32	70.1
	Processed with optically whitening agent for Wo	% 0.5 L	76.1	-1.0	0.32	0.33	80.2
		% 1 L	81.2	-0.2	0.31	0.33	77.5
		% 1.5 L	81.6	0.5	0.31	0.33	75.6
		% 2 L	81.1	0.4	0.31	0.33	78.0
Reductive washed with thiourea dioxide	Processed with optically whitening agent for PES	% 0.2 H	56.4	-5.4	0.32	0.34	71.4
		% 0.4 H	62.5	-5.6	0.32	0.33	70.5
		% 0.6 H	64.1	-5.2	0.32	0.33	70.0
		% 0.8 H	72.5	-5.2	0.32	0.33	70.7
	Processed with optically whitening agent for Wo	% 0.5 L	60.6	-2.1	0.32	0.34	77.7
		% 1 L	51.0	-2.7	0.32	0.34	75.9
		% 1.5 L	54.8	-3.0	0.32	0.34	76.1
		% 2 L	63.6	-1.9	0.32	0.34	78.5
Reductive washed with sodium borohydride	Processed with optically whitening agent for PES	% 0.2 H	67.1	-3.5	0.32	0.33	69.8
		% 0.4 H	71.2	-3.6	0.32	0.33	67.9
		% 0.6 H	76.5	-3.2	0.31	0.33	69.4
		% 0.8 H	75.5	-3.2	0.31	0.33	68.3
	Processed with optically whitening agent for Wo	% 0.5 L	67.4	-0.7	0.32	0.33	73.8
		% 1 L	77.6	-0.7	0.31	0.33	73.9
		% 1.5 L	86.2	-0.4	0.31	0.33	73.4
		% 2 L	80.6	-1.0	0.31	0.33	74.3

* H: Hostalux ETB Liq.; Optical whitening agent for PES, L: Leucophor BSB Liq.; Optical whitening agent for Wo



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If one of the components in the blend is optically whitened, the WI value increases dramatically, even at low concentrations of the optical whitening agents used. The best results for the samples, of which one of the components in the blend was optically whitened only, were obtained with sodium hydrosulphite washed and 0.8% Hostalux treated fabric, and also sodium borohydride washed and 1.5% Leucophor treated samples (WI = 85.2 and 86.2, respectively). Table 5 summarizes the results of the single-step and two-step processed samples, of which each of the components in the blend was optically whitened with suitable optical whitening agents.

Table 5: *The Whiteness Indexes of the samples which were bleached, treated with reductive clearing agents and also with optically whitened in the single-step or in the two-step processes.*

Reductive washing	Optically Whitening Process	Applied concentration	CIE Whiteness				
			WI	T _w	x	y	Y
Reductive washed with hydrosulphite	Two-step process; PES and Wo optically whitened	% 0.2 H- % 0.5 L	70.7	-2.2	0.32	0.33	76.9
		% 0.4 H- % 1 L	80.9	-0.1	0.31	0.33	72.4
		% 0.6 H- % 1.5 L	78.2	-0.7	0.31	0.33	73.8
		% 0.8 H- % 2 L	81.4	-0.7	0.31	0.33	75.7
	Single-step process; PES and Wo optically whitened at 110 °C	% 0.2 H- % 0.5 L	65.5	-5.4	0.31	0.32	72.3
		% 0.4 H- % 1 L	98.6	-0.5	0.30	0.32	68.7
		% 0.6 H- % 1.5 L	99.9	-0.2	0.30	0.32	67.6
		% 0.8 H- % 2 L	100.6	-0.1	0.30	0.32	68.6
	Single-step process; PES and Wo optically whitened at 95°C	% 0.2 H- % 0.5 L	92.7	-0.5	0.31	0.32	70.4
		% 0.4 H- % 1 L	97.2	-0.1	0.30	0.32	67.4
		% 0.6 H- % 1.5 L	97.3	0.0	0.31	0.32	68.7
		% 0.8 H- % 2 L	106.7	1.3	0.30	0.32	68.4
Reductive washed with thiourea dioxide	Two-step process; PES and Wo optically whitened	% 0.2 H- % 0.5 L	70.2	-3.0	0.31	0.33	76.9
		% 0.4 H- % 1 L	67.0	-3.0	0.31	0.33	75.6
		% 0.6 H- % 1.5 L	78.2	-0.7	0.32	0.33	75.6
		% 0.8 H- % 2 L	76.3	-2.0	0.32	0.33	76.4
	Single-step process; PES and Wo optically whitened at 110 °C	% 0.2 H- % 0.5 L	65.5	5.4	0.32	0.33	72.3
		% 0.4 H- % 1 L	81.0	-1.3	0.32	0.33	74.7
		% 0.6 H- % 1.5 L	83.1	-4.0	0.31	0.33	75.1
		% 0.8 H- % 2 L	84.1	-3.6	0.31	0.33	75.2
	Single-step process; PES and Wo optically whitened at 95°C	% 0.2 H- % 0.5 L	79.7	-3.8	0.31	0.33	74.3
		% 0.4 H- % 1 L	82.4	-3.6	0.32	0.33	74.1
		% 0.6 H- % 1.5 L	83.6	-3.2	0.31	0.33	73.8
		% 0.8 H- % 2 L	92.6	-2.2	0.31	0.32	78.3
Reductive washed with sodium borohydride	Two-step process; PES and Wo optically whitened	% 0.2 H- % 0.5 L	84.9	-1.0	0.31	0.33	74.9
		% 0.4 H- % 1 L	81.2	-2.0	0.31	0.33	69.2
		% 0.6 H- % 1.5 L	82.6	-1.2	0.31	0.33	70.3
		% 0.8 H- % 2 L	84.1	-1.4	0.31	0.32	69.2
	Single-step process; PES and Wo optically whitened at 110 °C	% 0.2 H- % 0.5 L	71.5	-3.6	0.32	0.33	70.7
		% 0.4 H- % 1 L	80.7	-3.8	0.31	0.32	70.2
		% 0.6 H- % 1.5 L	82.4	-3.5	0.31	0.32	68.3
		% 0.8 H- % 2 L	86.0	-2.9	0.31	0.32	69.2
	Single-step process; PES and Wo optically whitened at 95°C	% 0.2 H- % 0.5 L	70.2	-3.1	0.32	0.33	71.0
		% 0.4 H- % 1 L	70.8	-3.5	0.32	0.33	71.8
		% 0.6 H- % 1.5 L	88.4	-2.5	0.31	0.32	68.6
		% 0.8 H- % 2 L	88.4	-2.3	0.31	0.32	74.1

* H: Hostalux ETB Liq.; Optical whitening agent for PES, L: Leucophor BSB Liq.; Optical whitening agent for Wo

The best results obtained in the experimental work are printed in bold in Table 5. The application with 0.8% Hostalux and 2% Leucophor on 50/50% PES/Wo in a single-step process gave the best result. In Figure 1, the results with these concentrations are also compared in respect to the reductive washing agent.

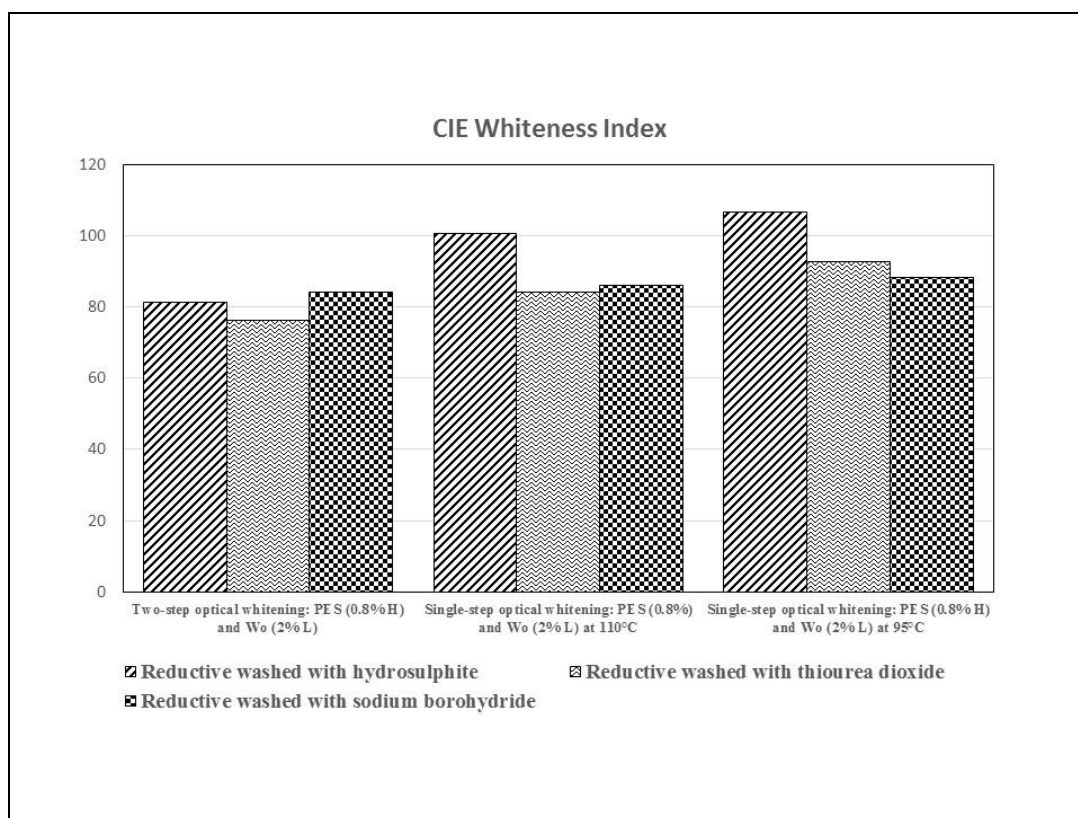


Fig. 1: CIE Whiteness Index values of the samples which were bleached, reductive washed and optically whitened (Optical whitening agents used: “H”: Hostalux ETB Liq. for PES and “L”: Leucophor BSB Liq. for wool).

The CIELab values of some of the untreated and treated samples with a CIE WI value having above 90 are given in Table 6 and Table 7, respectively.

Table 6: The CIELab values of the untreated sample and “the bleached and reductive washed” samples.

Sample	CIELab Values				
	L*	a*	b*	C*	h°
Untreated	86.35	0.13	10.99	10.99	89.32
Bleached and reductive washed with sodium hydrosulphite	88.45	-1.13	5.12	5.25	102.46
Bleached and reductive washed with sodium thiourea dioxide	88.65	0.65	8.20	8.23	85.49
Bleached and reductive washed with sodium borohydride	88.65	0.65	8.20	8.23	85.49



Table 7: The CIELab values of the treated samples with CIE WI > 90.

Sample / Process(*)	Applied Optic Concentration	CIELab Values				
		L*	a*	b*	C*	h°
HS, SS, 110°C	% 0.4 H- % 1 L	86.32	1.83	-6.37	6.62	286.03
HS, SS, 110°C	% 0.6 H- % 1.5 L	85.81	1.77	-6.84	7.06	284.54
HS, SS, 110°C	% 0.8 H- % 2 L	86.28	1.59	-6.82	7.0	283.10
HS, SS, 95°C	% 0.2 H- % 0.5 L	85.71	1.55	-5.33	5.55	286.21
HS, SS, 95°C	% 0.4 H- % 1 L	86.36	1.65	-6.47	6.67	284.30
HS, SS, 95°C	% 0.6 H- % 1.5 L	86.19	1.61	-6.57	6.76	283.80
HS, SS, 95°C	% 0.8 H- % 2 L	86.00	2.31	-6.24	6.65	290.36
TUD, SS, 95°C	% 0.8 H- % 2 L	88.94	2.27	-1.98	3.01	318.96

* HS: Sodium hydrosulphite; TUD: Sodium thiourea dioxide; SS: Single-step process; H: Hostalux ETB Liq.; L: Leucophor BSB Liq.

Table 7 summarizes the CIELab values of the samples which have WI > 90 only. As seen in Table 7, the treated samples have very close L* values to that of the untreated sample, but b* values are negative (blueish) and also T_w values are very close to zero. The values of T_w (Tinting value) when positive, indicate a greenish hue; when negative, indicate a reddish hue; and when zero, indicate a bluish hue with a dominant wavelength of 466 nm.

4. CONCLUSIONS

The optical whitening agent used for wool gave better results, and also the best results were obtained in single-bath treatments. The best whiteness value was obtained with hydrogen peroxide bleached and washed with sodium hydrosulphite samples which were later optically whitened with 0.8% Hostalux ETB Liq. and 2% Leucophor BSB Liq. at 95°C treatment. The tensile strength of the treated samples remained almost unchanged. The reductive washings were found to be effective in order to get a whitened fabric, and the most effective reducing agent was sodium hydrosulphite.

REFERENCES

- [1] S. R. Karmakar, *Chemical Technology in the Pre-Treatment Processes of Textiles*, Elsevier, 1999.
- [2] J. Shore, *Blend Dyeing*, Society of Dyers and Colourists, 1998.
- [3] D. Lewis and J. Rippon, *The Coloration of Wool and Other Keratin Fibres*, Wiley, 2013.
- [4] Australian Wool Innovation Ltd., "Superwhite Australian Merino using ColorClear™ WB Bleaching Technology", September 2006.
- [5] J. Gacen and D. Cayuela, "Comparison of wool bleaching with hydrogen peroxide in alkaline and acidic media", *Journal of the Society of Dyers and Colourists*, vol. 116, January, pp.13-15, 2000.
- [6] D. Yilmazer and M. Kanik, "Bleaching of Wool with Sodium Borohydride", *Journal of Engineered Fibers and Fabrics*, vol. 4, Issue 3, pp.45-50, 2009.
- [7] T. Harizi, S. Dhouib, S. Msahli and F. Sakli., *Bleaching Process Investigation of Tunisian Dromedary Hair*, *International Scholarly Research Notices Textiles* Volume 2013, 2013 <https://www.hindawi.com/journals/isrn/2013/532396/> (Last Visited: April 2017).
- [8] Clariant International Ltd., "Hostalux ETB Liq.", Technical Information, 102524.e.
- [9] Clariant International Ltd., "Leucophor BSB Liq.", Technical Information, 101236.07.01.e.