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Bleaching of 55/45 Wool/Cotton Blend Fabrics

Part II: Using Sodium Chlorite and Various Reducing Agents

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BLEACHING OF 55/45 WOOL/COTTON BLEND FABRICS PART II: USING SODIUM CHLORITE AND VARIOUS REDUCING AGENTS

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ABSTRACT

The bleaching of a 55/45 wool/cotton blended fabric with sodium chlorite and various reducing agents was investigated. In general, sodium chlorite was found not to be an effective bleaching agent. Reducing agents were found to produce higher degrees of whiteness, but still not as high as that attainable with hydrogen peroxide. Sodium dithionite, sodium metabisulphite and zinc formaldehyde sulphoxylate gave similar improvements in the degree of whiteness of the 55/45 wool/cotton blend fabrics. Bleaching by pad-dwell, pad-bake or pad-steam treatments generally produced similar results.

In addition a 33/67 wool/cotton blended fabric was included in this study.

INTRODUCTION

In an earlier report[1] the bleaching of 55/45 wool/cotton blends with hydrogen peroxide was described. The highest degree of whiteness was obtained by the use of silicate stabilised hydrogen peroxide in an overnight cold-pad-dwell process. More rapid bleaching, which gave a somewhat lower degree of whiteness, and with some loss of strength, was achieved using peroxide and ®Stabiliser C in a 15 minutes pad-steam process.

It was then decided to investigate the use of other bleaching agents on wool/cotton blends. The use of acidified or activated sodium chlorite for bleaching cellulosic fibres is, of course, well established in practice[2]. Cold pad procedures have been discussed by Garrett[3,4] and by Ney[5] and processes have been developed using, for example, formaldehyde sodium hypochlorite and ammonium perdisulphate as activators. There is also evidence that the use of formaldehyde or ammonium perdisulphate in a pad-steam brings about rapid bleaching[2]. It is to be expected, therefore, that at least the cellulosic portion of a wool/cellulosic blend will be bleached by a sodium chlorite treatment.

Various authors have reported on the feasibility of bleaching wool with acidified solutions of sodium chlorite, but such a technique has not yet been established in practice. The subject was extensively studied by Schirlé and Meybeck[6] and Serafimoff *et al*[7-9] Schirlé and Meybeck's important conclusion was that, under certain clearly defined conditions, wool can be bleached satisfactorily with sodium chlorite at *room temperature*. The extent of the

bleaching was shown to depend on the type of wool, the pH and the concentration of chlorite in the bleach bath. Merkle[10], investigating the action of sodium chlorite on wool at elevated temperatures, concluded that the wool showed no improvement in its degree of whiteness.

Earland and Johnson applied 10—20 *per cent* (m/v) chlorite to wool samples at a liquor to goods ratio of 30:1, during the course of their work on anti-felting treatments[11]. They found that a 10 *per cent* chlorite solution, buffered at pH 7—8 and containing 5 *per cent* formaldehyde, applied to wool at 18° C for 20 minutes, resulted in minimal damage. The deep yellowish-brown colour of the treated wool could be removed rapidly by an after-treatment using a diluted, acidified solution of sodium bisulphite. Unfortunately no whiteness measurements were reported by these authors, but it does appear worthwhile, on the basis of their work, and that of Serafimoff *et al* and Schirle and Meybeck, to examine the bleaching performance of activated chlorite in a cold pad-dwell system on wool and wool/cotton blends.

Although reducing agents are sometimes applied to cotton during scouring (e.g. ®BASF's Lufibrol KB processes[12]) they are not normally applied as part of a bleaching treatment. Hydrosulphite (dithionites) are, however, used extensively in wool bleaching, and sulphoxylates have also been proposed for this purpose[13-15]. Their effect on wool/cotton blends, however, has received practically no attention.

The purpose of this study was, therefore, to investigate the performance of sodium chlorite and various reducing agents, such as zinc formaldehyde sulphoxylate, sodium dithionite and sodium metabisulphite as bleaching agents on wool/cotton fabrics.

EXPERIMENTAL

Materials

Four materials comprising an all-wool fabric (266 g/m^2), an all-cotton fabric (145 g/m^2), a 55/45 wool/cotton blend (139 g/m^2) and a 33/67 wool/cotton blend (139 g/m^2) were used in this investigation.

Chemicals

Various concentrations of the following chemicals were used for bleaching purposes:

Sodium chlorite ($NaC\ell O_2$)
Zinc formaldehyde sulphoxylate (®Redusol Z, ®Blankit D)
Sodium dithionite ($Na_2S_2O_4$) and
Sodium metabisulphite ($Na_2S_2O_5$).

TABLE I

THE DEGREE OF WHITENESS OF FABRICS BLEACHED WITH VARIOUS CONCENTRATIONS OF ACTIVATED SODIUM CHLORITE BY THE PAD-DWELL PROCESS

Sodium Chlorite Treatment*	Reductive** After-Treatment	Degree of Whiteness (Percentage Reflection)			
		All-Wool	55/45 Wool/ Cotton	33/67 Wool/ Cotton	All-Cotton
Untreated Control		55,9	60,3	53,8	52,3
0,25% $NaClO_2$ + HCHO	—	56,5	55,6	54,1	50,9
0,25% $NaClO_2$ + HCHO	$Na_2S_2O_4$	58,4	62,5	55,3	54,2
0,25% $NaClO_2$ + HCHO	$Na_2S_2O_5$	58,4	62,4	55,3	59,3
0,5% $NaClO_2$ + HCHO	—	56,8	61,5	54,3	59,5
0,5% $NaClO_2$ + HCHO	$Na_2S_2O_4$	58,7	64,2	55,1	60,8
0,5% $NaClO_2$ + HCHO	$Na_2S_2O_5$	58,8	63,2	57,2	64,6
1,0% $NaClO_2$ + HCHO	—	56,6	62,0	55,5	66,3
1,0% $NaClO_2$ + HCHO	$Na_2S_2O_4$	58,7	64,6	57,3	66,8
1,0% $NaClO_2$ + HCHO	$Na_2S_2O_5$	59,4	64,0	56,7	67,9
2,0% $NaClO_2$ + HCHO	—	49,1	60,5	53,2	67,9
2,0% $NaClO_2$ + HCHO	$Na_2S_2O_4$	57,5	61,2	58,0	67,0
2,0% $NaClO_2$ + HCHO	$Na_2S_2O_5$	58,8	64,2	57,6	67,4
0,25% $NaClO_2$ + $(NH_4)_2S_2O_8$	—	57,2	61,2	54,5	58,5
0,25% $NaClO_2$ + $(NH_4)_2S_2O_8$	$Na_2S_2O_5$	59,3	64,2	57,6	60,7
0,5% $NaClO_2$ + $(NH_4)_2S_2O_8$	—	56,9	62,0	56,1	61,9
0,5% $NaClO_2$ + $(NH_4)_2S_2O_8$	$Na_2S_2O_5$	59,4	64,7	56,2	62,8
1,0% $NaClO_2$ + $(NH_4)_2S_2O_8$	—	56,3	62,0	57,7	65,3
1,0% $NaClO_2$ + $(NH_4)_2S_2O_8$	$Na_2S_2O_5$	59,5	64,6	55,6	65,3
2,0% $NaClO_2$ + $(NH_4)_2S_2O_8$	—	55,4	61,9	58,4	65,7
2,0% $NaClO_2$ + $(NH_4)_2S_2O_8$	$Na_2S_2O_5$	58,6	65,2	51,0	66,8

*Unbuffered

**EDTA was added to $Na_2S_2O_4$ or $Na_2S_2O_5$ solutions

TABLE II

THE DEGREE OF WHITENESS OF FABRICS BLEACHED WITH VARIOUS CONCENTRATIONS OF SODIUM DITHIONITE, SODIUM METABISULPHITE AND ZINC FORMALDEHYDE SULPHOXYLATE BY THE PAD-DWELL PROCESS

Treatment	Degree of Whiteness (Percentage Reflection)			
	All-Wool	55/45 Wool/Cotton	33/67 Wool/Cotton	All-Cotton
Untreated Control	55,9	60,3	53,8	52,3
4% $Na_2S_2O_4$	58,8	63,6	57,4	56,7
8% $Na_2S_2O_4$	60,0	64,9	56,6	56,4
12% $Na_2S_2O_4$	61,4	65,8	57,7	57,3
4% $Na_2S_2O_5$	59,1	64,5	57,4	57,7
8% $Na_2S_2O_5$	60,0	65,1	57,4	55,9
12% $Na_2S_2O_5$	61,5	66,1	57,6	57,3
4% Redusol Z	55,6	62,3	57,5	58,3
8% Redusol Z	59,9	64,7	60,1	59,1
12% Redusol Z	59,1	67,4	59,7	59,5
4% Blankit D	58,3	62,8	56,8	58,3
8% Blankit D	57,7	64,1	59,8	61,7
12% Blankit D	58,8	65,4	60,2	59,3

between the three bleaching techniques. Table III furthermore shows that, in general, the degree of whiteness of the fabrics increased when the pH of the bleaching solutions decreased. Treatment of the wool-rich blend with 8 *per cent* zinc formaldehyde sulphoxylate at pH 2,5 increased the degree of whiteness by about 7 units, and that of the cotton-rich blend by about 5 units.

TABLE III

THE EFFECT OF THE pH OF THE BLEACHING SOLUTION ON THE REFLECTANCE VALUES OF THE SAMPLES TREATED BY DIFFERENT BLEACHING TECHNIQUES

Treatment	pH	Degree of Whiteness (Percentage Reflection)											
		Pad-Dwell				Pad-Bake				Pad-Steam			
		All-Wool	55/45 Wool/ Cotton	33/67 Wool/ Cotton	All-Cotton	All-Wool	55/45 Wool/ Cotton	33/67 Wool/ Cotton	All-Cotton	All-Wool	55/45 Wool/ Cotton	33/67 Wool/ Cotton	All-Cotton
Untreated Control		55,9	60,3	53,8	52,3	55,9	60,3	53,8	52,3	55,9	60,3	53,8	52,3
1% $NaClO_2$ + HCHO	2,5	51,3	58,4	51,9	57,1	45,3	54,4	48,4	55,8	33,5	42,8	39,5	49,9
1% $NaClO_2$ + HCHO	3,5	50,5	57,3	48,3	56,6	44,1	53,9	46,1	53,5	34,8	47,2	37,7	51,5
1% $NaClO_2$ + HCHO	4,5	44,7	54,3	47,7	56,2	40,5	50,8	42,7	52,8	46,4	53,8	36,4	51,3
8% Redusol Z	2,5	61,4	67,4	59,6	57,9	60,3	66,0	57,5	56,6	62,1	67,3	58,5	59,6
8% Redusol Z	3,5	59,1	65,7	59,1	60,9	58,7	64,6	57,1	58,3	62,3	66,7	57,7	57,7
8% Redusol Z	4,5	58,6	65,0	58,5	58,6	57,7	65,7	57,1	55,9	62,1	66,2	57,9	57,0
8% Blankit D	2,5	62,5	67,2	58,7	57,8	60,8	66,2	58,4	55,9	62,4	66,7	57,6	57,6
8% Blankit D	3,5	57,3	63,5	57,6	57,0	58,2	64,5	56,1	54,5	60,8	65,6	57,4	57,4
8% Blankit D	4,5	57,5	63,1	57,2	56,6	57,7	63,8	56,7	55,6	59,3	63,6	58,0	56,9

TABLE IV

THE ALKALI SOLUBILITY OF THE ALL-WOOL SAMPLES TREATED WITH VARIOUS BLEACHING AGENTS BY THE PAD-DWELL METHOD

Treatment	Reductive * After-Treatment	Alkali Solubility (%)
Untreated Control		12,5
0,25% $NaClO_2$ + HCHO		11,5
0,25% $NaClO_2$ + HCHO	$Na_2S_2O_4$	12,5
0,25% $NaClO_2$ + HCHO	$Na_2S_2O_5$	12,1
0,5% $NaClO_2$ + HCHO		12,2
0,5% $NaClO_2$ + HCHO	$Na_2S_2O_4$	16,3
0,5% $NaClO_2$ + HCHO	$Na_2S_2O_5$	16,4
1,0% $NaClO_2$ + HCHO		19,2
1,0% $NaClO_2$ + HCHO	$Na_2S_2O_4$	18,7
1,0% $NaClO_2$ + HCHO	$Na_2S_2O_5$	18,9
2,0% $NaClO_2$ + HCHO		18,5
2,0% $NaClO_2$ + HCHO	$Na_2S_2O_4$	17,9
2,0% $NaClO_2$ + HCHO	$Na_2S_2O_5$	17,0
0,25% $NaClO_2$ + $(NH_4)_2S_2O_8$		12,7

0,5% $NaClO_2 + (NH_4)_2S_2O_8$		13,6
0,5% $NaClO_2 + (NH_4)_2S_2O_8$	$Na_2S_2O_5$	15,0
1,0% $NaClO_2 + (NH_4)_2S_2O_8$		16,6
1,0% $NaClO_2 + (NH_4)_2S_2O_8$	$Na_2S_2O_5$	15,8
2,0% $NaClO_2 + (NH_4)_2S_2O_8$		19,0
2,0% $NaClO_2 + (NH_4)_2S_2O_8$	$Na_2S_2O_5$	17,2
4% $Na_2S_2O_4$		14,4
8% $Na_2S_2O_4$		14,9
12% $Na_2S_2O_4$		15,1
4% $Na_2S_2O_5$		13,4
8% $Na_2S_2O_5$		13,8
12% $Na_2S_2O_5$		14,0
4% Redusol Z		13,9
8% Redusol Z		12,0
12% Redusol Z		12,5
4% Blankit D		15,2
8% Blankit D		15,1
12% Blankit D		14,8

* EDTA was added to $Na_2S_2O_4$ or $Na_2S_2O_5$ solutions

The alkali solubilities of the all-wool treated with sodium chlorite and various reducing agents are given in Table IV. The results show that the alkali solubility of the wool increased with an increase in the concentration of sodium chlorite. The various reductive after-treatments had little effect on the alkali solubility of the samples treated with sodium chlorite. It can furthermore be seen that the various zinc formaldehyde sulphoxylate reducing agents had little effect on the alkali-solubility of the wool.

Table V shows the effect of the pad-dwell, pad-bake and pad-steam methods, as well as different pH values of the bleaching solutions, on the alkali-solubility of the wool. In general, the pH value of the solution did not seem to have a large or consistent effect on the alkali-solubility of the wool. The alkali solubility of the samples seem to increase in the following order: pad-dwell, pad-bake and pad-steam treatment. In the case of the pad-dwell treatment all the samples had alkali solubilities lower than 18 *per cent*, whereas the pad-steam method resulted in values as high as 26 *per cent*.

TABLE V

THE ALKALI SOLUBILITY OF THE ALL-WOOL SAMPLES TREATED WITH VARIOUS BLEACHING AGENTS AT DIFFERENT pH VALUES BY THE PAD-DWELL, PAD-BAKE AND PAD-STEAM METHODS

Treatment	pH	Alkali Solubility (%)		
		Pad-Dwell	Pad-Bake	Pad-Dwell
Untreated Control		12,5	12,5	12,5
1% $NaClO_2$ + HCHO	2,5	16,1	14,8	14,0
1% $NaClO_2$ + HCHO	3,5	12,8	14,4	13,2
1% $NaClO_2$ + HCHO	4,5	17,5	22,4	11,9
8% Redusol Z	2,5	13,2	22,8	26,3
8% Redusol Z	3,5	16,3	16,7	22,1
8% Redusol Z	4,5	11,9	16,2	25,6
8% Blankit D	2,5	15,1	15,6	25,7
8% Blankit D	3,5	15,3	14,9	17,7
8% Blankit D	4,5	16,6	21,5	19,4

SUMMARY AND CONCLUSIONS

Various methods for the bleaching of wool/cotton blends with either sodium chlorite or different reducing agents have been studied and compared with results obtained on an all-cotton and an all-wool fabric. It was found that the treatment of wool/cotton blends with *sodium chlorite* had only a small effect on the degree of whiteness of these fabrics, compared to the all-cotton fabric where a significant increase in the degree of whiteness was obtained by using chlorite.

The effect of various *reducing* agents on the degree of whiteness of the fabrics was then studied. The 55/45 wool/cotton fabric could be effectively bleached using reducing agents, although the increase in the degree of whiteness was less than that found previously with hydrogen peroxide. Sodium dithionite, sodium metabisulphite and two commercial zinc formaldehyde sulphoxylate reducing agents were found equaly effective in increasing the degree of whiteness of the 55/45 wool/cotton fabric. In the case of the 33/67 wool/cotton blend, however, zinc formaldehyde sulphoxylate produced better results than the other reducing agents.

The effect of the different methods of bleaching, i.e. the pad-dwell, pad-bake and pad-steam bleaching methods was then investigated. There was little difference in the degree of whiteness for the three different methods when zinc formaldehyde sulphoxylate was used as the bleaching agent. It was furthermore found that the degree of whiteness of the fabrics increased as the pH of the bleaching solution was decreased from 4,5 to 2,5. Treatment of the 55/45 wool/cotton blend with 8 *per cent* zinc formaldehyde sulphoxylate at pH 2,5 increased the degree of whiteness by about 7 units and that of the 30/70 wool/cotton blend by about 5 units.

In general, the reductive treatments had a small effect on the alkali solubility of the wool samples which tended to increase in the following order: pad-dwell, pad-bake and pad-steam treatments. The alkali-solubility of wool treated according to the pad-dwell process was less than 18 *per cent.*

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THE USE OF PROPRIETARY NAMES

®Redusol Z is a proprietary name of Messrs ICI, ®Blankit D of Messrs BASF, ®Tergitol Speedwet of Messrs Union Carbide and ®Stabiliser C of

Messrs Laporte. The fact that chemicals with proprietary names have been used in this report does not in any way imply that SAWTRI recommends them or that there are not others equally good or better.

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TABLE V, page 10: For last column, read "pad-steam" for "pad-dwell"