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Bleaching of 55/45 Wool/Cotton Blend Fabrics

Part I: Using Hydrogen Peroxide

by

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BLEACHING OF 55/45 WOOL/COTTON BLEND FABRICS
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ABSTRACT

The response of three 55/45 wool/cotton blend fabrics to bleaching with peroxide by conventional cold-pad-dwell and pad-steam methods under both acid and alkaline conditions has been examined, and compared with the performance of all-wool and all-cotton fabrics bleached under identical conditions. The highest whiteness per unit of peroxide applied, without significant degradation, was obtained by the use of silicate-stabilised peroxide in an overnight cold-pad-dwell process. More rapid bleaching, to somewhat lower whiteness maxima and with some sacrifice of strength, was achieved using peroxide and Stabiliser C in a 15 minute pad-steam process.

INTRODUCTION

No details appear to have been published concerning the bleaching of fabrics made from wool/cotton intimately blended yarns.

The purpose of the present investigation was to establish suitable methods for bleaching 55/45 wool/cotton fabrics, using hydrogen peroxide, and based on conventional, economical procedures.

Wool is normally bleached with hydrogen peroxide, batchwise, under relatively mild (acid or alkaline) conditions [1–4]. This treatment may be followed by the application of a reducing agent, typically sodium dithionite or sodium bisulphite, to achieve a full white [3–4]. Sulphoxylates, also, have been proposed for bleaching wool, either batchwise or continuously, hot or cold [4–6]. Cotton is bleached with hydrogen peroxide (either batchwise, semi or fully continuously) [7–10], but more rigorous alkaline conditions are generally used than those applied to wool. Although reducing agents are sometimes applied to cotton during (alkaline) scouring (to protect the cellulose from degradation by atmospheric oxygen), they are not normally applied as part of a bleaching treatment.

Wool/cotton blend fabrics might be expected, in view of the foregoing, to respond well to bleaching with peroxide under mildly acidic or mildly alkaline conditions; such fabrics appear particularly suited to bleaching by a cold-pad-dwell process [12–13], and response to this type of treatment has therefore been examined in some detail.

EXPERIMENTAL

MATERIALS

Three different 55/45 wool/cotton blends were used (a twill, a whipcord and a barathea), together with an all-wool and an all-cotton fabric.

Wool/Cotton blends

These were woven from an intimately blended R42 tex, S 650/2 Z860 yarn; the twill had a density of 135 g/m^2, 84 ends x 76 picks/cm; the whipcord 255 g/m^2, 100 ends x 72 picks/cm, and the barathea 300 g/m^2, 84 ends x 84 picks/cm.

All-Wool fabric

This was woven from a 42 tex yarn into a plain weave having 21 ends x 21 picks/cm, and a density of 184 g/m^2. The wool had an alkali solubility of 12,3 *per cent*.

All-Cotton fabric

This was woven from a 17,5 tex yarn into a plain weave (sheeting type), having 32 ends x 30 picks/cm and a density of 125 g/m^2. The fabric was desized with Rapidase 20 X (Soc. Rapidase). The cotton had a fluidity of 2,1 poise^{-1}.

Samples cut from these fabrics measured 15 cm by 30 cm.

Chemicals

Hydrogen peroxide (50% m/m) was used at various concentration levels. In the text and tables, concentration is expressed as percentage H_2O_2 (100% m/m) on air-dry mass of fabric.

For acidification, laboratory reagent grade formic acid was used. For the alkaline treatments either Stabiliser C (9 g/ℓ, Laporte) was used, together with Viscavin CA Special (2 g/ℓ, Chem. Fab. Tübingen) and the disodium salt of EDTA (1 g/ℓ), or sodium silicate solution (16,25 g/ℓ, 36 *per cent* SiO_2, 18 *per cent* Na_2O) was used, together with caustic soda (3,51 g/ℓ) magnesium sulphate (0,3 g/ℓ) and the disodium salt of EDTA (1 g/ℓ).

In all the experiments Tergitol Speedwet (5 g/ℓ, non-ionic, Union Carbide) was used as wetting agent.

METHODS

Bleaching Techniques:

The following techniques were used for bleaching:

(i) padding cold and storing the fabric in roll-form (in a closed plastic bag) overnight (the so-called cold-pad-dwell process);

(ii) as (i) but giving a 15 minute steaming treatment at 100°C and atmospheric pressure in a Benz Steamer, after overnight dwell (the cold-pad-dwell-steam process); and

(iii) padding cold and immediately steaming, again in a Benz Steamer, for up to 45 minutes, but usually 10 – 15 minutes) (the pad-steam process). Drying was carried out at 100°C and atmospheric pressure on a Hoffman press.

The wet pick-up was determined by weighing the fabric samples before and after padding, and was approximately 50 *per cent*, except for those experiments in which sodium silicate was used, where it was 100 *per cent*.

Whiteness Determination:

The degree of whiteness (reflectance) was determined using a Zeiss Elrepho-Spectrophometer at 457 nm with magnesium oxide as basic standard (reflectance 100 *per cent* with F46 filter inserted in the incident (Xenon) light beam.

Physical Tests:

Losses in tear strength and bursting strength were determined using, respectively, the Elmendorf Tear Tester and the Mullen bursting strength apparatus. Fluidities on cotton and alkali solubilities on wool were determined using standard methods (BS 2610, BS 3568) [14–15].

RESULTS AND DISCUSSION

1. BLEACHING WITH HYDROGEN PEROXIDE ACIDIFIED TO pH 4,5

(i) Cold-Pad-Dwell Process

The technique adopted is one well-known in the treatment of woollen

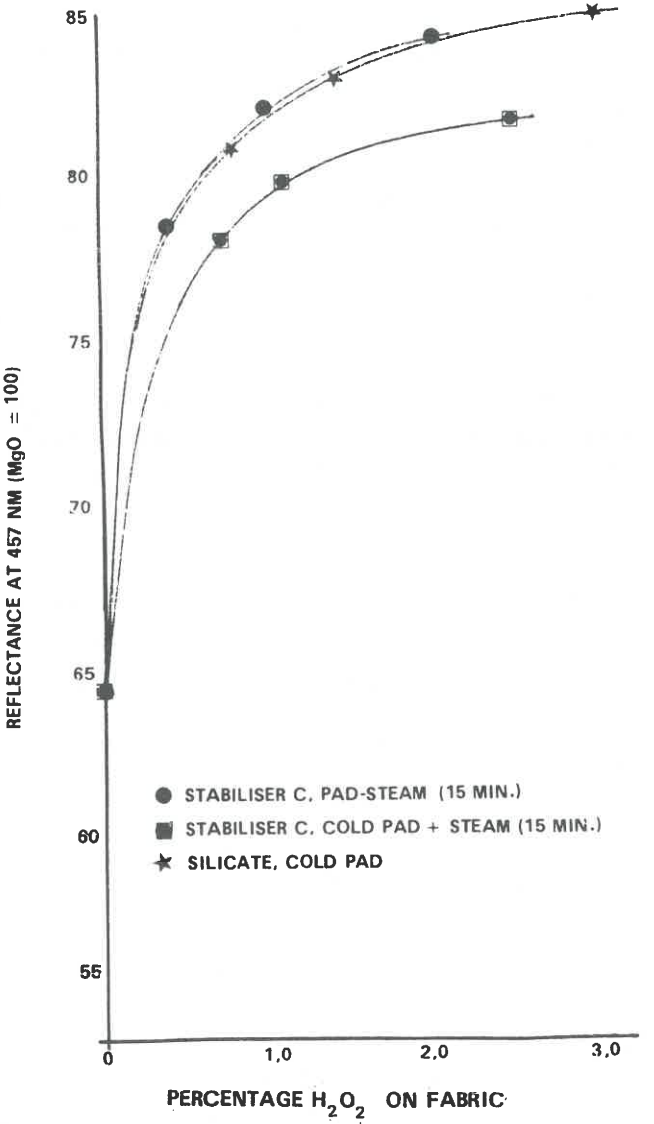

Figure 1 *The effect of initial peroxide concentration on reflectance of all-cotton fabric (125 g/m²)*

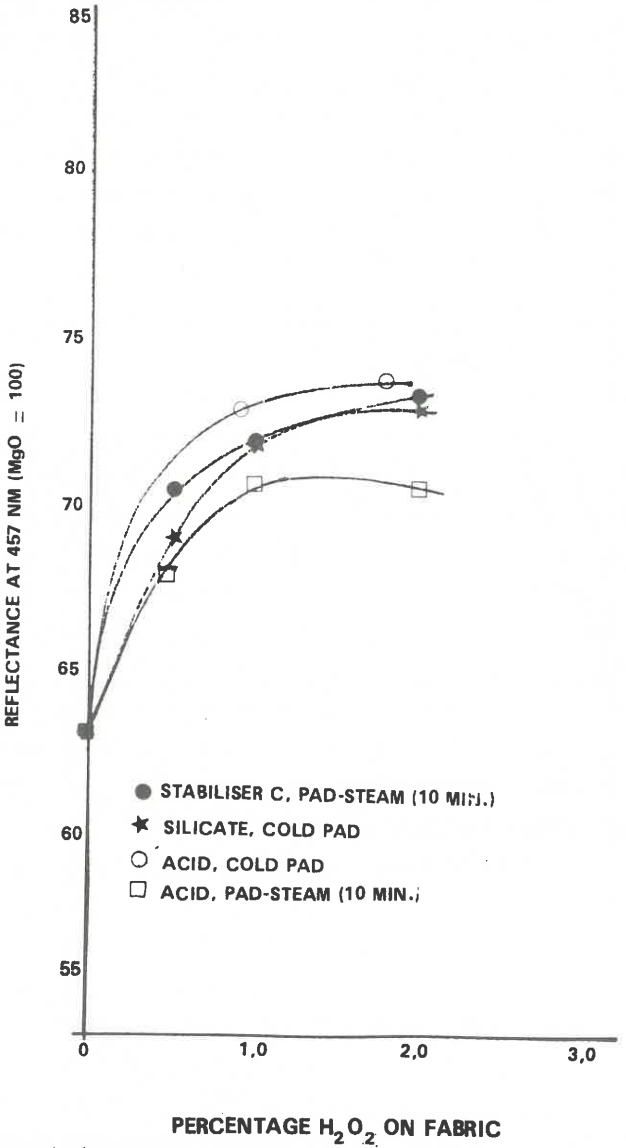

Figure 2 The effect of initial peroxide concentration on reflectance of all-wool fabric (184 g/m²)

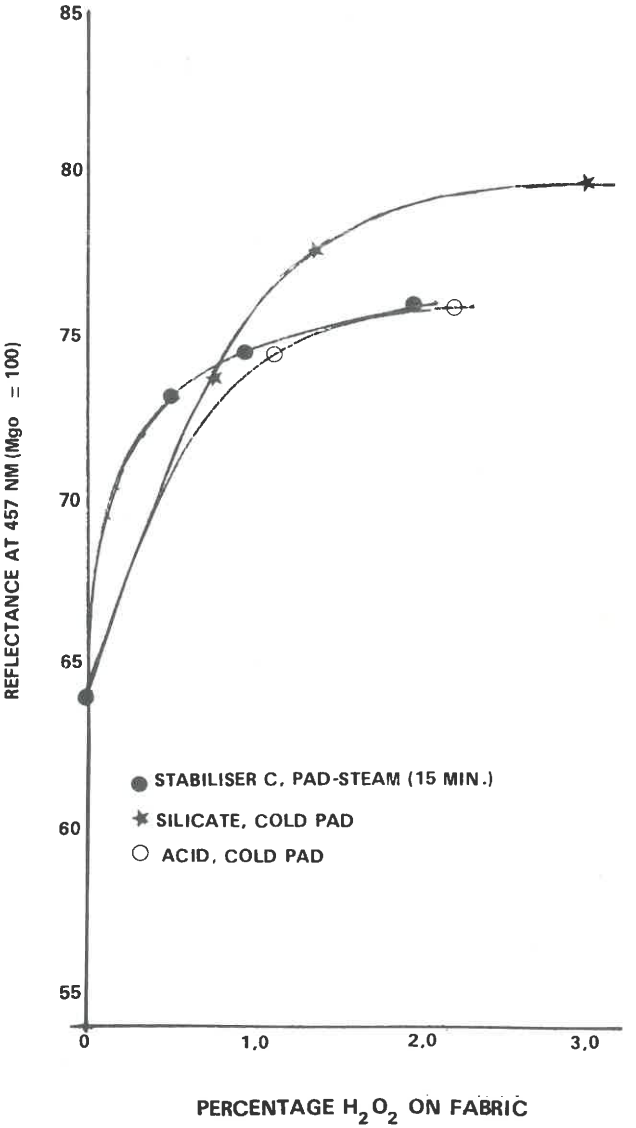

Figure 3 *The effect of initial peroxide concentration on reflectance of 55/45 wool/cotton twill fabric (135 g/m²)*

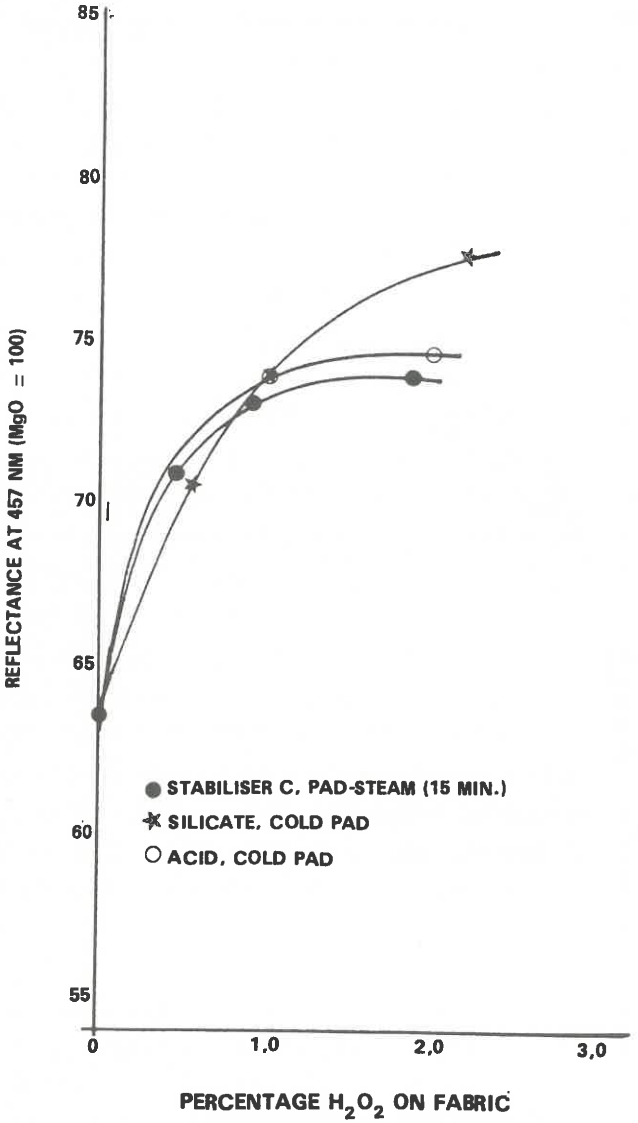

Figure 4 The effect of initial peroxide concentration on reflectance of 55/45 wool/cotton barathea fabric (300 g/m²)

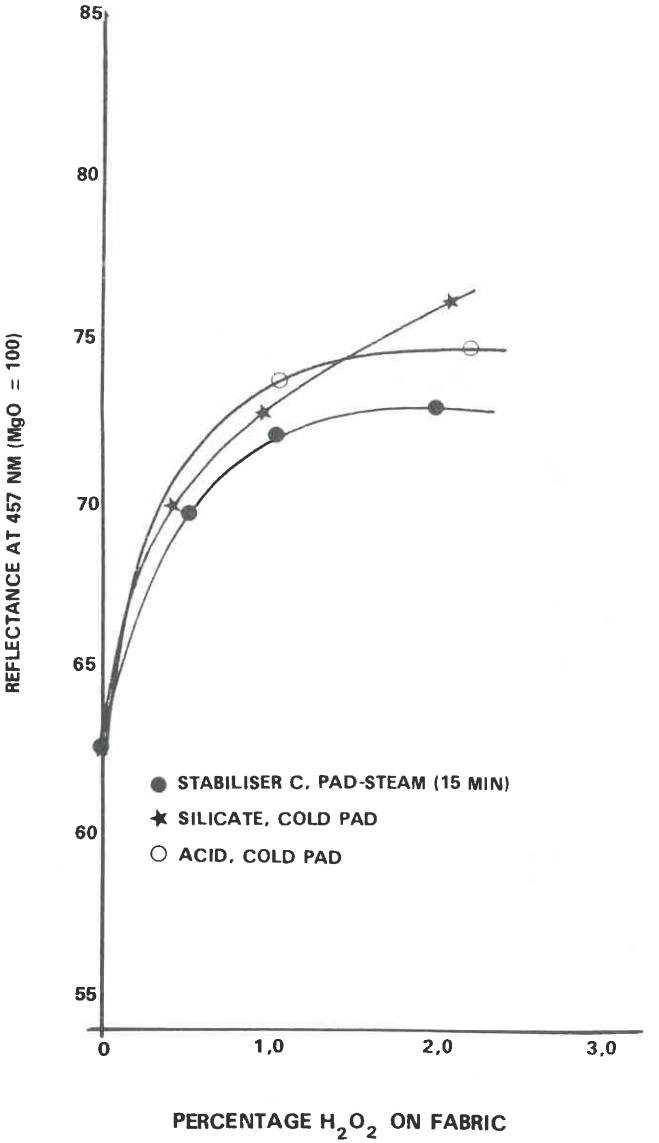

Figure 5 The effect of initial peroxide concentration on reflectance of 55/45 wool/cotton whipcord fabric (355 g/m²)

(iii) Pad-Steam Process

Because the blends showed little or no yellowing when steamed for 15 minutes following a cold-pad-dwell process, it was thought worthwhile to investigate the effects of immediate steaming with no overnight dwell. Also, Cegarra [16] has reported that *wool* can be bleached with peroxide by five-minute steam-exposure. The results are presented in Table III.

TABLE III

DEGREES OF WHITENESS BURSTING STRENGTH AND TEAR STRENGTH LOSS OF FABRICS BLEACHED WITH H_2O_2/FORMIC ACID (pH 4,5) BY THE PAD-STEAM PROCESS

Fabric	Steaming time (min.)	Reflectance (%)				Loss in Bursting Strength (%) at 1% H_2O_2	Loss in Tear Strength (%) at 1% H_2O_2
		Un-treated	H_2O_2 (%)				
			0,5	1	2		
All wool	5	63,3	68,2	70,4	71,7	—	—
	10		68,1	70,7	70,6	4,6	—
	15		66,9	69,1	68,7	—	0
	30		—	65,4	65,7	—	—
All cotton	5	64,7	70,4	71,7	73,5	—	—
	10		72,5	73,5	77,8	—	4,3
	15		74,0	78,1	81,9	19,1	—
55/45 Wool/ cotton twill	5	64,2	69,2	70,7	72,5	—	—
	10		70,6	72,4	74,8	8,2	0
	15		70,8	73	72,5	24,9	—
	30		—	69	65,8	—	—
	45		—	64,3	58,6	—	—
55/45 Wool/ cotton barathea	5	63,7	68	70	72,3	—	—
	10		69	71,9	73,9	9,1	6,5
	15		69,6	71,7	74,4	9,3	—
	30		—	70,7	70,4	—	—
	45		—	68,0	64,6	—	—
55/45 Wool/ cotton whipcord	5	62,7	68	68,5	70,8	—	—
	10		68	70,9	73,0	4,6	6,1
	15		68,3	70,8	72,2	6,9	—
	30		—	68,4	67,2	—	—
	45		—	63,2	58,2	—	—

Steaming of the two heavier blends was found to be possible for up to 15 minutes without deleterious effect on whiteness and with less than ten *per cent* bursting strength loss (less than seven *per cent* tear strength loss). Although there was a progressive improvement in whiteness of the all-cotton fabric as steaming time was increased, seed coat remained visible and the bursting strength loss was almost 20 *per cent* after 15 minutes steaming. In the case of the all-wool fabric, steaming for up to ten minutes produced an increase in whiteness of some seven units (see Figure 2) without significant strength loss; steaming for longer periods resulted in a decrease in whiteness, becoming progressively more noticeable, the higher the concentration of peroxide used and the longer the steaming time.

When steaming the blends for longer than 15 minutes, a decrease in whiteness was also found. This was particularly noticeable when the peroxide concentration exceeded one *per cent*. Steaming for only five minutes produced an inferior bleach.

2. BLEACHING WITH ALKALINE HYDROGEN PEROXIDE

(i) Cold Pad-Dwell Process

The material was passed through peroxide bleaching solution (stabilised with either Stabiliser C or sodium silicate), and between squeeze rollers with the pressure adjusted to give a suitable expression, prior to overnight ageing, washing off and drying.

The results obtained are shown in Table IV.

The improvement in whiteness brought about by exceeding one *per cent* H_2O_2/Stabiliser C on the mass of fabric was relatively small (generally less than two units) and therefore uneconomic. In the case of silicate-stabilised peroxide (Figures 1 – 5), it appears that it may be worthwhile to use a higher concentration level, say 1,5 *per cent* H_2O_2 on the mass of fabric, on the heavier blends.

The use of approximately one *per cent* peroxide on the blends resulted in an increase in whiteness of 8 – 9 units when using Stabiliser C, and 10 – 14 units when using sodium silicate; somewhat smaller increases were obtained on the all-wool fabric, somewhat larger increases on the all-cotton.

Bursting strength and tear strength losses were very low under the chosen conditions.

In the case of the all-wool fabric, although silicate-stabilised peroxide was a more effective bleach then H_2O_2 / Stabiliser C, the result was slightly inferior in terms of whiteness to that obtained using peroxide acidified to pH 4,5. The alkali solubility of the wool bleached with silicate-stabilised

TABLE IV

DEGREES OF WHITENESS, TEAR AND BURSTING STRENGTH LOSSES OF FABRICS BLEACHED WITH ALKALINE H_2O_2 BY THE COLD-PAD-DWELL PROCESS

Fabric	Reflectance (%)							Bursting Strength Loss (%)	Tear Strength Loss (%)	
	Un-treated	H_2O_2/Stabiliser C (%)			H_2O_2/Silicate C (%)			H_2O_2/Silicate (%)	H_2O_2/Stabiliser C (%)	H_2O_2/Silicate (%)
		0,5	1	2	0,5	1	2	2	1	1
All wool	63,3	69,3	68,2	72,6	69,1	72,1	73,1	1,7	0	–
All cotton	64,7	76,4	76,3	77,9	81,0	83,1	84,9 *	0,9	1,7	0
55/45 Wool/ cotton twill	64,2	71,7	72,7	74,7	73,9	77,8	79,8 +	1,4	2,2	–
55/45 Wool/ cotton barathea	63,7	70,9	71,9	73,2	70,7	74,0	77,6	3,1	2,7	0,3
55/45 Wool/ cotton whipcord	62,7	69,1	71,8	71,0	69,9	72,8	76,3	0,8	2,4 (2% H_2O_2)	–

* Almost no motes visible. H_2O_2 3% o.m.f.

\+ 3% H_2O_2 o.m.f.

peroxide was 19 *per cent,* compared with 12,3 *per cent* for the unbleached fabric.

On the all-cotton fabric, the silicate-stabilised peroxide bleach produced a large increase in whiteness (approx. 18 units) with insignificant strength loss *and very good mote removal.* The fluidity of the bleached cotton was very low (2,3 poise $^{-1}$).

In the case of the blends, the use of silicate-stabilised peroxide afforded an increase in whiteness at least as high as that obtainable with acidified peroxide, significantly higher at the two *per cent* H_2O_2 level. The residual silicate was readily removed from the fabrics by cold rinsing. Bursting strength losses were low. The process is therefore a viable one for 55/45 wool/cotton blends.

(ii) Cold Pad-Dwell-Steam Process

Peroxide was applied as in Section (i) above, but, after overnight storage, and before drying, the fabric was steamed for 15 minutes.

The steaming treatment was confined to those fabrics padded with H_2O_2/Stabiliser C. The results are shown in Table V. The results indicate that, for the blends, the short after-steam generally caused a small but barely perceptible improvement in whiteness; there was certainly no significant deterioration in whiteness under the chosen conditions. The all-cotton fabric showed a significant improvement in whiteness on steaming; the fluidity of the bleached cotton was low (3,4 poise $^{-1}$). Bursting strength losses were all well within acceptable limits and lower than those of blends treated by the cold pad-dwell-steam process using acidified peroxide. The whiteness obtained was in all cases inferior to that given by a cold pad-dwell process using silicate-stabilised peroxide.

In the case of the *all-wool* fabric, the results obtained by cold pad-dwell using H_2O_2/ Stabiliser C (with or without after-steam) were inferior to those obtained using acidified peroxide. The alkali solubility of the bleached wool was, however, more acceptable (18 *per cent*).

On the blends also, at the one *per cent* (optimum) level of peroxide application, results were inferior to those achieved using acidified peroxide in a pad-dwell process. In this latter process, however, there is a greater risk of degradation occurring, especially during steaming, because of the influence of acid on the cellulosic portion of the blend.

TABLE V

DEGREES OF WHITENESS AND BURSTING STRENGTH LOSS OF FABRICS BLEACHED WITH H_2O_2/STABILISER C BY THE COLD PAD-DWELL-STEAM PROCESS

Fabric	Reflectance (%)				Bursting Strength Loss (%)	
	Un-treated	H_2O_2 (%)			H_2O_2 (%)	
		0,5	1	2	1	2
All-wool	63,3	69,6	67,9	71,8	5,3	6,8
All-cotton	64,7	78,2	79,9	81,8 +	–	8,4
55/45 Wool/Cotton twill	64,2	72,0	73,0	76,0	3,5	5,8
55/45 Wool/Cotton barathea	63,7	70,4	72,0	73,8	–	7,5
55/45 Wool/Cotton whipcord	62,7	69,7	72,4	72,9	–	– *

+ Motes still present

* Tear Strength loss 5,3 *per cent*

(iii) Pad-Steam Process

It is of interest to compare the properties of the 55/45 wool/cotton blends, padded with H_2O_2/ Stabiliser C and immediately subjected to a short steaming process with those of samples steamed after padding with acidified peroxide (Table III). The results are presented in Table VI.

In the case of all-wool fabric, steaming for up to 10 minutes with one *per cent* H_2O_2/ Stabiliser C produced an increase in whiteness of the order of nine units (Figure 2) (slightly less than with cold acidified peroxide, but as high as with cold silicate-stabilised peroxide, and higher than cold H_2O_2/ Stabiliser C), with no significant bursting strength loss; the alkali solubility, however, was 24 *per cent*. A decrease in whiteness was observed when steaming was prolonged beyond 10 minutes (as with acidified peroxide), and the alkali solubility after 15 minutes' steaming was relatively

high (35 *per cent*).

There was a progressive improvement in whiteness of the all-cotton fabric as steaming was prolonged, for all concentrations of peroxide used, and the results were higher than those obtained with cold H_2O_2/ Stabiliser C (with or without an after-steam), or acid peroxide (pad-steam), and not significantly lower than cold H_2O_2/ silicate (see Figure 1). However, some seed-coat was still evident at the end of the treatment. Bursting strength loss, in the case of the all-cotton fabric, was of the order of 11 – 12 *per cent*, i.e. less than when acidified peroxide was used, as expected. Bleaching with one *per cent* H_2O_2/ Stabiliser C, steaming for 15 minutes, resulted in the low fluidity of 3,4 poise $^{-1}$.

TABLE VI

DEGREES OF WHITENESS, BURSTING STRENGTH AND TEAR STRENGTH LOSSES OF FABRICS BLEACHED WITH H_2O_2/STABILISER C BY THE PAD-STEAM PROCESS

Fabric	Steaming time (min.)	Reflectance (%)				Bursting Strength Loss (%)		Tear Strength Loss (%)	
		Un-treated	H_2O_2 (%)			H_2O_2 (%)		H_2O_2 (%)	
			0,5	1	2	1%	2%	1%	2%
All-wool	5	63,3	70,3	70,8	73,3	–	–	–	–
	10		70,5	72,0	73,3	0,8	0	–	–
	15		71,2	71,3	72,5	–	–	0	0
All-Cotton	5	64,7	72,8	74,5	77,0	–	–	–	–
	10		75,1	77,3	79,8	–	–	4	8
	15		78,6	82,1	84,1+	12,1	10,6	–	–
55/45 Wool/ cotton twill	5	64,2	70,4	71,7	74,1	–	–	–	–
	10		71,9	73,0	74,8	–	–	0	6
	15		73,3	74,6	76,0	12,7	8,3	–	–
55/45 Wool/ cotton barathea	5	63,7	68,2	70,2	73,0	–	–	–	–
	10		69,2	71,9	73,5	–	–	7	11
	15		71,0	73,2	73,9	12,7	7,3	–	–
55/45 Wool/ cotton whipcord	5	62,7	68,6	69,9	70,9	–	–	–	–
	10		68,1	71,0	73,0	–	–	6	5
	15		69,8	72,1	73,0	4,8	7,9	–	–

\+ still contains motes

With the 55/45 wool/cotton blends, a 15-minute steaming period produced increases in whiteness of about ten units, with no more than a 13 *per cent* loss in bursting strength, even in the case of the relatively lightweight twill fabric. The whiteness was as high, or almost as high, as that obtained by a cold pad-dwell using acidified peroxide at pH 4,5 but was inferior to that achieved when using cold silicate-stabilised peroxide and batching overnight (Figures 3 – 5). The results were significantly better than those obtained by padding with acidified peroxide and steaming, and H_2O_2/ Stabiliser C is, therefore, the preferred medium for rapid pad-steam bleaching of these blends, e.g. by short J-box.

Some of the results of this investigation are depicted in Figures 1 – 5.

SUMMARY AND CONCLUSIONS

A number of different procedures for bleaching wool/cotton blends with hydrogen peroxide have been studied, and compared with the results obtainable on an all-cotton and an all-wool fabric.

Results are presented which illustrate that, using padding techniques, the highest degree of whiteness, per unit of peroxide applied, was achieved using:

on 55/45 wool/cotton:	cold pad-dwell, H_2O_2/ silicate;
on all-cotton:	cold pad-dwell, H_2O_2/ silicate, or 15 minute pad-steam, H_2O_2/ Stabiliser C;
on all-wool:	cold pad-dwell, H_2O_2/ formic acid.

Degrees of whiteness almost as high were obtained using:

on 55/45 wool/cotton:	15 minute steam, H_2O_2/ Stabiliser C, or cold pad-dwell, H_2O_2/ formic acid;
on all-cotton:	cold pad-dwell, H_2O_2/ Stabiliser C plus 15 minute steam;
on all-wool:	10 minute steam, H_2O_2/ Stabiliser C, or cold pad-dwell, H_2O_2/ silicate.

Using the above procedures, strength losses were within acceptable limits, and were generally lower when an alkaline, as opposed to acid, medium was used for bleaching. In bleaching the wool/cotton blends there is a greater risk of degradation (of the cellulosic portion) if acidified peroxide is used, rather than stabilised mildly alkaline peroxide (which does not significantly damage wool). None of the processes examined produced

a completely mote-free cotton but cold silicate-stabilised peroxide came close to achieving this.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the co-operation and assistance of the Departments of Textile Physics and Textile Finishing.

THE USE OF PROPRIETARY NAMES

The fact that certain products with proprietary names have been used in this investigation in no way implies that SAWTRI recommends them or that there are not others which may be equal or better.

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