Bleaching of Woven Cotton/Wool Fabric with TAED/H_2O_2 on a Jig Machine

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Introduction

The textile industry is well aware of the different bleaching conditions for cotton and wool. For the bleaching of cotton/wool blends, techniques that are efficient for both fibre components and cause minimum fibre damage, are essential.

In order to minimise the damage to the wool component, industrial jig bleaching procedures for cotton/wool blends are based predominantly on the conventional wool bleaching process with hydrogen peroxide under mildly alkaline conditions, followed by a reductive bleaching treatment. Under these bleaching conditions, the cotton component in the blend cannot be adequately bleached, leading to an overall unsatisfactory bleaching performance and product quality of the blend. In addition, due to the relatively tight structures of woven substrates, a longer treatment time and/or more severe conditions are often required for wovens to achieve an equivalent white to the corresponding knitted goods. Although slight modifications of the peroxide bleaching conditions have been attempted in industry to improve the bleaching effectiveness, they often compromise the product quality.

Recently, the availability of peroxide activators has provided opportunities for the design and implementation of a superior bleaching technology. In a previous study, we have successfully developed a package bleaching process for cotton/wool yarns by utilising a TAED (tetraacetylethylenediamine) activated peroxide system [1]. The bleach activator reacts with hydrogen peroxide in solution to form peracetic anion, which has greater bleaching properties than the original peroxide at low temperatures and mildly alkaline conditions. The recipes and procedures developed for yarn packages can be readily adapted for bleaching cotton/wool knitted fabrics.

Bleaching of woven fabrics, however, is generally carried out in open width to avoid running marks on the fabric. A jig is one of the commonly used machines in industry for wet processing woven cotton fabrics [2]. Figure 1 is a schematic structure of a traditional jig machine. In operation, the fabric is wound onto a roll, and run through the bleaching bath at the bottom of the machine, and onto a second roll. The action is then reversed, until all of the fabric is wound onto the second roll. Jig processing generally offers the advantage of simple and economic operation with the fabric at open width during processing. In contrast to the severe liquor circulation and relatively long liquor conditions previously used for yarns and knitted fabric, jig processing involves a low liquor ratio (e.g. 2.5:1 to 6:1), with the liquor agitated only by the movement of the fabric through the bath. These operating conditions not only require a modification of the level of chemical usage, but also increase the difficulty in TAED application, due to its low solubility in water. Modified bleaching recipes and procedures are required to meet jig bleaching conditions.

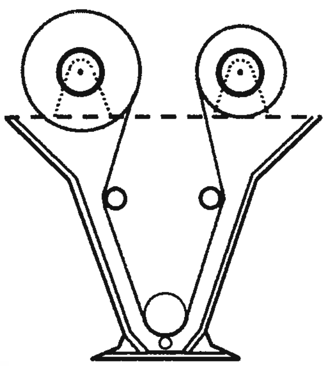

Figure 1 Cross-section of a simple dye jig; fabric marked in red

In addition, there is increased interest in jig processing of open width piece goods, especially when small and high quality lots are required to satisfy market requirements.

This investigation has focused on the development of a commercially viable process for bleaching woven cotton/wool blends with a TAED activated peroxide system for optimum product performance.

Experimental

Materials

Woven cotton/wool (70/30) blended fabric (desized) was used in this study. The fabric was woven from Colana® yarn supplied by Rocklea Spinning Mills. The initial whiteness index (CIE) of the fabric was 20.1. The main chemicals used in this study are listed in Table 1.

Bleaching methods

A sequential two-bath bleaching process (oxidative-reductive) was examined. In all cases, the bleaching bath was set at 30-40°C and heated to 60°C at 1.5-2°C/min. The temperature was held at 60°C for 60 minutes for oxidative bleaching, and 30 minutes for reductive bleaching. The basic oxidative bleaching bath consisted of a stabilizer, hydrogen peroxide (H_2O_2), TAED, Albatex FFC and surfactants with an initial pH set at

10.0. In reductive bleaching, 1.5 g/l thiourea dioxide or 3g/l sodium hydrosulfite was used in conjunction with Verolan NBO base. A liquor ratio of 6:1 was used. The bleaching equipment used was a laboratory jig (Ernst Benz AG).

Table 1. Chemicals used

Product	Function
C.I. Fluorescent Brightener 90	Optical brightening agent
Albatex FFC (Ciba)	Wetting and deaerating agent
Tinoclarite WO (Ciba)	Stabilizer
Verolan NBO base (Rudolf Chemie)	Sequestrant
Tubingal NM (CHT Group)	Softener, nonionic
Sandosoft OEW (Clariant)	Softener, slightly cationic
Ceraperm MW (Clariant)	Softener, nonionic
TAED (Clariant/Warwick)	Peroxide activator

Other chemicals used were commercial grade.

Evaluation of the bleached samples

Whiteness index (CIE whiteness) of the bleached and unbleached substrate was measured on a Gretag Macbeth Color-Eye 7000A Spectrophotometer.

Results and Discussion

Jig bleaching conditions for cotton/wool blends with TAED/H_2O_2

In the case of jig bleaching of woven cotton/wool blends, a relatively high concentration of the bleaching agent is required. The following conditions have been used:

Set bath at 30°C with:

Stabiliser	x g/l
H_2O_2 (50% w/w)	25-30 g/l
TAED	2 g/l
Surfactants	2-4 g/l
Deaerating agent	0.5-1 g/l
Initial pH	10.0 -10.3
Liquor-to-goods ratio	6 : 1

The bath is set at 30°C, and run for 5 minutes. Heat to 60°C at 2°C/minute and hold at 60 °C for 60 minutes. Drain. Hot rinse and cold rinse. The stabiliser used in the laboratory trial was Tinoclarite WO. Other alternative stabilisers such as Stabilizer SIFA (Clariant) may be used. Stabilzer SIFA should be used in conjunction with alkali, such as sodium carbonate, to maintain the required pH.

The jig bleaching results for the cotton/wool blend are shown in Figure 2. The overall bleaching achieved using the TAED/H_2O_2 based system is far superior to that bleached with H_2O_2 alone. The resultant whiteness and cotton seed coat fragment removal (assessed visually) were also equivalent to that achieved at the long liquor conditions.

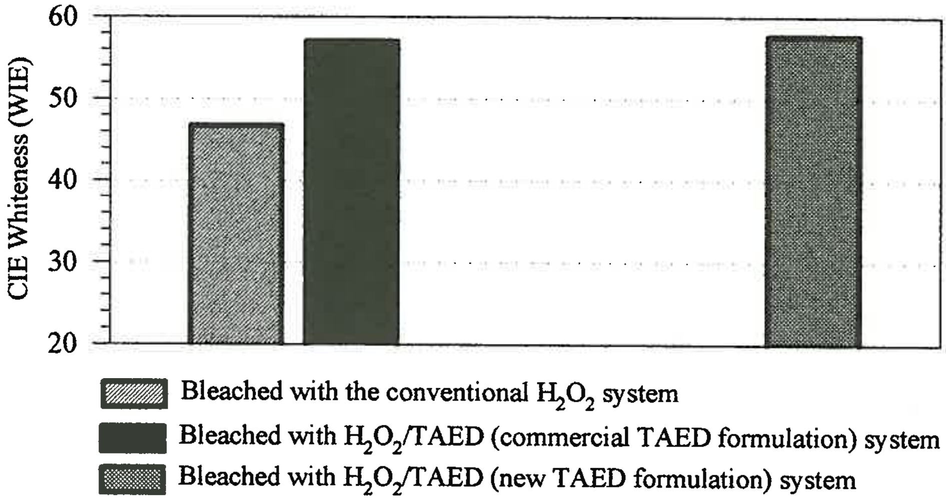

Figure 2 Whiteness of the cotton/wool blend bleached with a jig machine

Development of a new TAED formulation

One disadvantage of the TAED/H_2O_2 system for industrial textile bleaching is the low solubility of TAED in water and the difficulty of obtaining a homogeneous solution. This problem is more critical for jig bleaching, where the liquor to goods ratio is low, the TAED concentration is relatively high and the liquor is not circulated during bleaching. If TAED is not completely dissolved before adding to the bleaching bath, the undissolved TAED will settle to the bottom of the vessel and remain undissolved for a lengthy period. This would affect the bleaching efficiency, and pose difficulties in industrial application of the bleaching process. This disadvantage has hindered the wide application of the TAED activated peroxide system in certain types of machinery and processing routes.

To improve the industrial viability of the process, a new TAED formulation was developed. This newly formulated TAED exhibited excellent solubility in cold water (dilutable with cold or warm water in any proportion) and high storage stability. The formulation ingredients used are cheap and environmentally safe. The bleaching effectiveness of the newly formulated product is equivalent to the original commercial TAED powder (when the TAED powder was predissolved completely before adding to the bleach bath), as shown in Figure 2. This development will underpin the further development of the TAED/H_2O_2 system in continuous and semi-continuous bleaching processes, which are more difficult situations in terms of chemical concentrations, liquor temperature and circulation.

Reductive Bleaching and Softening

When an intense and stable white is required for a wool containing substrate, especially if it is to be followed by the application of a fluorescent brightener, an alkaline peroxide or peroxide/TAED bleach followed by reductive bleach is necessary. The jig reductive bleaching conditions and procedures are as follows:

Set bath at 40°C with:

Verolan NBO Base	0.25- 0.50 g/l
Reductive bleaching agent	x g/l (as specified)
C.I. Fluorescent Brightener 90	0.6 - 0.7% o.w.f.

Heat at 1.5°C/minute to 60°C and hold for 30 minutes. Hot rinse and cold rinse.

Softening is often applied following bleaching. An example is given below:

Set bath at 40°C with:

Monosodium phosphate	1 g/l
Softener	2- 4 % o.w.f.

Raise temperature to 50°C and hold for 30 minutes. Drain.

The results of the woven cotton/wool blend treated by the full bleaching (TAED/H_2O_2 - reducing agent) and softening processes are shown in Figure 3. A high degree of the substrate whiteness is achievable using the developed process. The results also indicate that selection of an appropriate compatible softener is important to gain optimal product performance from bleaching. Nonionic softeners are specially suitable for optically brightened goods. Cationic softeners impair the effect of anionic optical brighteners. Although Sandosoft OEW is only slightly cationic and considered suitable for optically brightened goods, it still shows a negative effect on final whiteness of the substrate under the conditions examined.

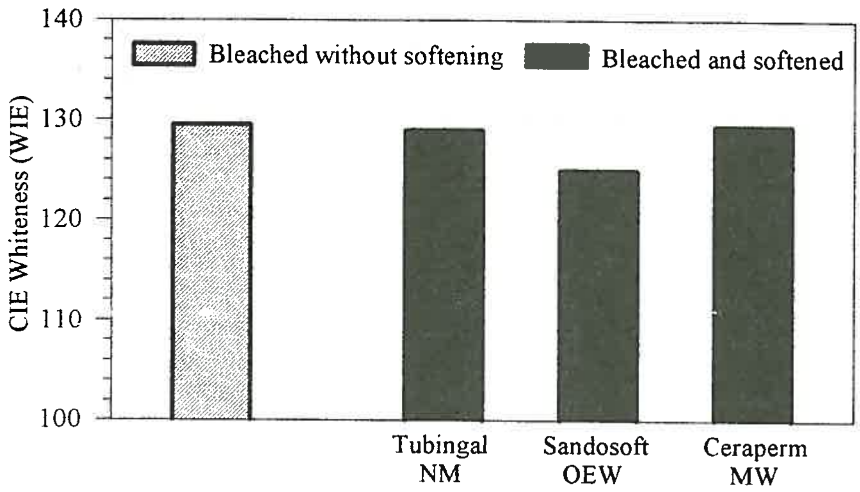

Figure 3 Whiteness of the woven cotton/wool blend achieved at full bleaching and softening stages

Conclusions

This study has demonstrated a practical process for bleaching woven cotton/wool blends with a jig machine. The new TAED formulation developed improves the industrial viability of the process. As a result, significantly enhanced bleaching effectiveness (i.e. whiteness and seed coat removal) on woven cotton/wool blends was achieved with this TAED activated peroxide system. The results also show the importance of selection of chemicals such as softeners and treatment conditions for optimum product performance.

Acknowledgment

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