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# Radio Frequency Bleaching of Cotton Fabrics

## Part I: An Introductory Study

by

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# RADIO FREQUENCY BLEACHING OF COTTON FABRICS
# PART I: AN INTRODUCTORY STUDY

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## ABSTRACT

*The bleaching of cotton fabrics with radio frequency (RF) energy was investigated and compared with conventional pad-steam bleaching. It was found that cotton fabrics could be bleached successfully with hydrogen peroxide in a RF energy field. The performance of various different hydrogen peroxide stabilisers was also studied. All of these proved to be effective, and with some, significantly whiter fabrics were obtained with RF energy than with pad-steam bleaching. No detectable damage was done to the fabrics by RF energy bleaching as shown by fluidity and bursting strengths values.*

## INTRODUCTION

Bleaching is an important preparation process in the textile industry, particularly in the cotton sector. For most outlets, the natural colouring matter in cotton must be removed[1]. The estimated world cotton consumption for 1984-1985 is 72,6 million bales (one bale is 217,7 kg) and in 1983 cotton's share of the USA retail market, excluding carpets, was 39% of all textile fibres[2]. Both the importance and scale of cotton bleaching are, therefore, readily apparent.

Processes for conventional cotton bleaching are well documented. Both batchwise and continuous bleaching are usually carried out under alkaline conditions using oxidising agents[3,4]. The main oxidising agent used in cotton bleaching is hydrogen peroxide. Its advantages over other oxidising agents such as sodium hypochlorite, are related to its ready adaptability to continuous processing.

Since the early days of hydrogen peroxide bleaching, sodium silicate has been used to stabilise the peroxide against too rapid decomposition[5]. However, sodium silicate can form a hard, damaging silicate deposit on metal surfaces and on fabrics[6]. Consequently there has been an active search over recent years for organic compounds to replace sodium silicate, and some have already gained acceptance in textile mills. Some authors, however, believe that there is no possibility of ever finding a single chemical compound to equal the stabilising effect of sodium silicate[7].

Apart from the search for sodium silicate replacements, other trends in continuous bleaching have been towards both open-width processing and improved energy efficiency[5]. Energy consumed in bleaching may be divided between heat required to attain bleaching temperatures and sustained heat losses[8]. Energy saving in bleaching, of course, is only part of a general trend

**Radio Frequency Treatment**

After padding, the fabric samples were placed in polyethylene bags, excess air removed and the bags sealed and placed manually in the tube of a Fastran RF Continuous Top Dyeing Machine. The principle of operation of this machine has been described previously [16,21]. A wet wool sliver was used to transport the bags continuously through the machine. The generator current was set at 400 mA to produce a power output of 1,04 kW. This resulted in a temperature of 110° C within the tube during bleaching. The radiation frequency was 27,12 MHz and the total treatment time 45 min. The time spent by each sample in the RF energy field was about 5 min.

**Pad-Steam Treatment**

Fabric samples were also subjected to a conventional steaming treatment after padding. Padding of the samples for steam treatment was carried out at the same time and under identical conditions to those used in the RF energy treatment. The padded fabric samples were placed in polyethylene bags as described above and the bags suspended in a Benz Laboratory Steamer by means of stainless steel hooks. The steaming times and temperatures used for each stabiliser were those recommended by the supplier concerned. In those cases where such recommendations were not available, steaming was carried out at 110° C for 45 min. These latter conditions are not only typical of certain established industrial pad-steam cotton bleaching processes[5], but are also similar to those described previously for the RF energy process.

**After-treatment**

Following RF energy and pad-steam treatments, the fabric samples were rinsed thoroughly to remove all residual chemicals[3] and press-dried with a hand iron.

**Tests**

The whiteness indices (WI) of the fabrics were obtained using a Hunterlab D25M-9 Colorimeter which measured the X, Y and Z CIE tristimulus values and automatically calculated values from the equation:

$$WI = 4 \frac{Z}{1,18103} - 3Y$$

This equation is in accordance with ASTM Method E313-73 and AATCC Test Method 110-1975[22].

Cotton fluidities were determined according to standard method SABS

115. Bursting strengths were measured using a Mullen bursting strength apparatus.

## RESULTS AND DISCUSSION

### Effect of Bleaching on Cotton Whiteness

The whiteness indices of fabrics bleached using the RF energy and pad-steam treatments and with various stabilisers, are shown in Table 3. From these data it may be seen that both treatments resulted in good whitenesses compared with those of the untreated controls. It is also clear that RF energy bleaching compared well with pad-steam bleaching. Table 3 shows convincingly that cotton fabrics can be bleached successfully with hydrogen peroxide in a RF energy field.

A considerable whitening action during bleaching was achieved with all the stabilisers. There was, however, significant variation between the different chemical groups, as well as within the groups themselves. Generally speaking, stabiliser E gave the best average performance during pad-steam bleaching, and stabiliser A the best effect with the RF energy process. Sodium silicate also appeared to be very effective in RF energy bleaching. It has been suggested that stabilisers containing phosphoric compounds may have advantages over other organic stabilisers[7]. The limited evidence in Table 3 did not support this contention since stabilisers F, G and H did not show any conspicuous advantage over the others. There was indeed no obvious correlation between the chemical group of a stabiliser and its effect on bleaching performance.

The use of sodium silicate and stabiliser A resulted in exceptionally good RF energy bleaching performances. In both these cases, whiteness indices were higher for the RF energy process than for pad-steaming. Among the organic stabilisers, stabiliser A's performance appeared to be unique in RF energy bleaching, but not very different from that of stabiliser B, for example, in pad-steam bleaching. The performance of a stabiliser in a pad-steam process can clearly not always be used to assess its suitability to RF energy bleaching.

Both knitted and woven fabrics were successfully bleached with hydrogen peroxide. In general, the knitted fabrics were less white after bleaching than the woven fabrics. This was undoubtedly due, at least partially, to the yellowness of the knitted fabric before bleaching (WI of 5).

### Effect of Bleaching on Cotton Strength

#### Fluidity

Cotton fluidities were determined for both the scoured medium-weight woven and knitted fabric samples. The values obtained are shown in Table 4.

## TABLE 3

## WHITENESS INDICES OF FABRICS BEFORE AND AFTER BLEACHING

| Stabiliser | Light-Weight | | Medium-Weight | | | | Heavy-Weight | | Knitted | | Mean of Five Fabrics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Loomstate | | Scoured | | | | | | | |
| | RF | Pad-steam | RF | Pad-steam | RF | Pad-steam | RF | Pad-steam | RF | Pad-steam | RF | Pad-steam |
| Sodium Silicate | 73 | 64 | 42 | 35 | 67 | 59 | 54 | 43 | 52 | 35 | 58 | 47 |
| A | 72 | 52 | 54 | 31 | 69 | 45 | 51 | 33 | 48 | 21 | 59 | 36 |
| B | 39 | 52 | 18 | 27 | 30 | 39 | 24 | 28 | 23 | 28 | 27 | 35 |
| C | 51 | 59 | 32 | 40 | 36 | 46 | 28 | 34 | 32 | 32 | 36 | 42 |
| D | 66 | 70 | 39 | 46 | 47 | 56 | 31 | 42 | 38 | 42 | 44 | 51 |
| E | 60 | 69 | 47 | 53 | 65 | 63 | 36 | 41 | 37 | 39 | 49 | 53 |
| F | 47 | 59 | 37 | 43 | 40 | 50 | 32 | 36 | 33 | 21 | 38 | 42 |
| G | 55 | 65 | 41 | 44 | 45 | 51 | 34 | 41 | 31 | 38 | 41 | 48 |
| H | 51 | 48 | 32 | 34 | 38 | 47 | 31 | 33 | 33 | 20 | 37 | 36 |
| I | 54 | 60 | 35 | 40 | 41 | 46 | 36 | 39 | 38 | 46 | 41 | 46 |
| J | 49 | 52 | 39 | 35 | 39 | 44 | 29 | 30 | 31 | 15 | 37 | 35 |
| CONTROL | 26 | | 5 | | 26 | | 17 | | 5 | | 16 | |

## TABLE 4

## COTTON FLUIDITIES OF BLEACHED AND UNBLEACHED FABRICS

| Stabiliser | Fluidity ($Pa^{-1}s^{-1}$) | | | |
|---|---|---|---|---|
| | Scoured, Medium-Weight Woven Fabric | | Knitted Fabric | |
| | RF | Pad-Steam | RF | Pad-Steam |
| Sodium Silicate | 34 | 32 | 30 | 23 |
| A | 65 | 32 | 30 | 23 |
| B | 27 | 32 | 23 | 25 |
| C | 34 | 29 | 22 | 25 |
| D | 23 | 29 | 28 | 19 |
| E | 30 | 35 | 27 | 41 |
| F | 39 | 23 | 35 | 20 |
| G | 32 | 32 | 22 | 23 |
| H | 37 | 25 | 26 | 20 |
| I | 47 | 41 | 28 | 27 |
| J | 33 | 30 | 25 | 19 |
| Unbleached | 20 | | 21 | |

Fluidity in cuprammonium hydroxide solution may be taken as a measure of cotton strength[23]. High fluidity values indicate a degraded cotton. Mauersberger[24] has reported that fluidities of between 10 and 50 $Pa^{-1}s^{-1}$ indicate very mildly scoured and bleached cottons whereas cottons with fluidity values between 50 and 100 $Pa^{-1}s^{-1}$ are considered to be normally scoured and bleached. On this basis, the values shown in Table 4 imply that neither RF nor pad-steam bleaching with any of the stabilisers used, resulted in overbleached or damaged cotton. Some stabilisers appeared to result in slightly higher cotton fluidity values with RF bleaching than with pad-steam bleaching. Notable among these was stabiliser A and, to a lesser extent, stabilisers F and H. The differences between RF energy and pad-steam bleached cotton fluidities were not consistent.

### Bursting Strength

The bursting strengths of both the knitted and the scoured, medium weight woven fabric samples were determined and the values are shown in Table 5. These results indicated that there was little or no damage to the cotton fibre by either bleaching process. This applied to each of the peroxide stabilisers examined.

## TABLE 5

## BURSTING STRENGTHS OF BLEACHED AND UNBLEACHED FABRICS

| Stabiliser | Bursting Strength ($kN/m^2$) | | | |
|---|---|---|---|---|
| | Scoured Medium-Weight Woven Fabric | | Knitted Fabric | |
| | RF | Pad-Steam | RF | Pad-Steam |
| Sodium Silicate | 1412 | 1494 | 1314 | 1249 |
| A | 1448 | 1559 | 1308 | 1275 |
| B | 1523 | 1416 | 1350 | 1281 |
| C | 1321 | 1432 | 1389 | 1304 |
| D | 1363 | 1402 | 1281 | 1337 |
| E | 1429 | 1399 | 1268 | 1314 |
| F | 1383 | 1324 | 1239 | 1213 |
| G | 1268 | 1376 | 1334 | 1337 |
| H | 1281 | 1471 | 1275 | 1327 |
| I | 1416 | 1458 | 1330 | 1272 |
| J | 1464 | 1455 | 1265 | 1363 |
| Unbleached/Rinsed | 1402 | | 1308 | |

## SUMMARY AND CONCLUSIONS

The bleaching of cotton fabrics by hydrogen peroxide in a radio frequency (RF) machine was investigated and compared with pad-steam bleaching. Examination of whiteness index and strength of the fabrics after bleaching, showed that bleaching in a RF energy field was a feasible process.

A number of different hydrogen peroxide stabilisers were examined. All of these resulted in successfully bleached cotton fabrics by both RF energy and pad-steam processes. The magnitude of the bleaching action, however, varied with the different stabilisers. For two of the stabilisers examined, namely sodium silicate and a particular organic sequestrant, RF energy bleaching produced considerably whiter fabrics than the pad-steam process.

Fluidity and bursting strength values revealed that little or no fibre damage had occurred during bleaching by either process or with any of the stabilisers.

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## THE USE OF PROPRIETARY NAMES

The names of proprietary products where they appear in this report are mentioned for information only. This does not imply that SAWTRI recommends them to the exclusion of other similar products.

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