**EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN: 2319-5045**
**Volume 2, Issue 1, January-June, 2013, Available online at: www.eduzonejournal.com**

# Cotton Bleached with Sodium Perborate and Tetra Acetyl Ethylenediamine

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**ABSTRACT**

**Bleaching the scoured cotton cloth with sodium perborate and tetra acetyl ethylenediamine has been attempted in the present work. There have been experiments with different chemical concentrations, temperatures, and treatment times. The bleaching action on cotton results from hydrogen peroxide released when sodium perborate reacts with water in a bleaching bath. The results of this innovative procedure are compared to those of conventionally bleached fabric using only hydrogen peroxide. The results reveal that the modified bleaching process may utilize the generated hydrogen peroxide at a rate of up to 96%, whereas the standard bleaching procedure only utilizes 70%.The simplified bleaching process also satisfies the criteria for an environmentally friendly approach by requiring less water and energy. The whiteness index is maintained while the weight, tearing, and tensile strength are reduced compared to traditional bleaching. Conventional bleaching yields a CIE whiteness of 61 compared to the adjusted formula. Cotton, Hydrogen peroxide, Sodium perborate, Tetraacetyl ethylenediamine, and Bleaching Are All Part of the Bleaching Process.**

## INTRODUCTION

The modern textile industry is conscious of reducing energy use during wet processing to be more sustainable and profitable. Bleaching with hydrogen peroxide is helpful, but only if done quickly or at a low temperature. Decomposition of peroxide in traditional peroxide bleaching is more effective at higher temperatures due to its inefficacy at lower temperatures1. Only by creating a per-acetate anion may hydrogen peroxide be used for low-temperature bleaching. It is important to note that this reaction is both caustic and unstable. For low-temperature bleaching in the laundry, tetra acetyl ethylenediamine (TAED) is used as a bleach activator with a detergent. The quality of cellulosic fabrics can be enhanced using the TAED active bleaching technique.

White, odorless, and soluble in water, sodium perborate is an inert powder. When exposed to water, it undergoes hydrolysis, resulting in the formation of hydrogen peroxide and borate3,4. Peracid or peroxy acid, a potent oxidant5, is produced when hydrogen peroxide, water, and TAED combine. The potential redox value is nearly 2.3 V, compared to 1.8 V for a peroxide/water mixture.

Sodium perborate was employed as the oxidizing agent, while TAED was used as the activator in this research. Taguchi analysis was used to examine the relationship between the whiteness of treated fabrics and the processing parameters of temperature, dwell time, and sodium perborate and TAED concentrations. The whiteness index, strength loss, carboxyl group concentration, and copper number of treated cotton are used to determine the quality of the bleached fabric. There is a comparison to the standard bleaching method. Both bleaching baths' residual hydrogen peroxide concentrations are also assessed.

### Experimental

Experiments were conducted using a 72 x 56 plain woven scrubbed 100% cotton fabric of 240 g/m2. The count of the warp and the weft yarns was the 20s. The following are some characteristics of the cleaned fabric:

| Property | Value |
|---|---|
| Tensile strength, kgf | |
| Warp wise | :35.16 |
| Weft wise | :34.49 |
| Tearing strength, gmf | |
| Warp wise | :1721.60 |
| Weft wise | :1846.28 |
| Whiteness index (CIE) | :33.16 |

Loba Chemicals provided sodium perborate (bleaching), hydrogen peroxide (bleaching), and sodium silicate (stabilizer); Noida Chemicals supplied TAED (activator); Fisher Chemicals supplied sodium hydroxide (alkali); and Merck (I) Ltd supplied magnesium sulfate (water hardness). The LR grade was utilized for all of the compounds above.

**Methods**
Using a 'Mathis Labomat' (high-temperature, high-pressure beaker machine), we bleached a 10 g sample of scoured cotton fabric at a low temperature, 1:20 material-to-liquor. The cloth samples were then washed with clean water and air-dried after this process. Both established and novel bleaching techniques are outlined below:

**(i) The Tried-and-True Method**
The cotton cloth has been scouring, conventional bleaching, hot wash, cold wash, and finally, cold wash. Hydrogen peroxide (three volumes), sodium hydroxide (one percent), sodium silicate (three grams per liter), 90 degrees Celsius (four hours), and time all figure into the standard recipe.

**(ii) Suggested Method**
Fabric made from scouring cotton; Bleaching with a twist; Washing at hot and cold temperatures; Repeat. Minitab 13, a statistical data analysis program, was used to conduct a Taguchi study to determine which parameters produced the best outcomes. Saving money on R&D is possible using the Taguchi technique since it streamlines the process of gathering data for designing robust systems against changes in the environment, manufacturing variance, and wear and tear. Table 1 provides the values of the relevant parameters. Sixteen distinct recipe variations were chosen. Table 2 displays the recipes in detail.

**Analyses and Checks**
Hydrolysis of sodium perborate in the presence of water results in hydrogen peroxide and borate forming, as depicted in Reaction below.

$$NaBO_3.4H_2O \rightarrow NaBO_2 + H_2O_2 + 3H_2O \quad \ldots (1)$$

**Table 1: Quality Control Indicators that were analyzed**

| Parameter | Value |
|---|---|
| Sodium perborate , g/L | 10, 15, 20, 25 |
| TAED, g/L | 1, 2, 3, 4 |
| Temperature, °C | 40, 50, 60, 70, |
| Time, min | 30, 60, 90, 120 |

$$H_2O_2(g/L) = \frac{0.0017 \times A \times 1000}{V}$$

**Parameter**
A is the 0.1 N $KMnO_4$ concentration read from a burette, and V is the milliliter sample volume. The amount of leftover hydrogen peroxide in bleach baths was also estimated using a similar method. We used a Konica Minolta 3600d spectrophotometer, the CIE formula, a D-65 light source, and a 10° observer to determine the whiteness indices of our bleached samples.

Samples of scoured and bleached fabrics were tested for tensile strength in the warp and weft directions using an Instron tensile tester (Model No. 5565) and the American Society for Testing and Materials (ASTM) standard D-5035 (1995). Using the IS-6489 (1971) method, we determined the tearing strength of scoured and bleached cloth in both the warp and weft directions using an Instron tensile tester (Model No. 5565).

IS used the 1560 - 1974 (Reaffirmed 1999) technique to calculate the number of carboxylic groups in the samples.

Cotton fabric bleached using the standard, and modified processes had its copper number measured by the international standard (IS: 200: 1989).

**DISCUSSION AND RESULTS**

In order to enhance the quality of the fabric through value-added procedures like dying, printing, and finishing, various contaminants and components in cotton must be adequately eliminated during pre-treatment.

Table 2 — Taguchi analysis chart

| Recipe | Sodium perborate, g/L | TAED g/L | Temp °C | Time min |
|---|---|---|---|---|
| T1 | 10 | 1 | 40 | 30 |
| T2 | 10 | 2 | 50 | 60 |
| T3 | 10 | 3 | 60 | 90 |
| T4 | 10 | 4 | 70 | 120 |
| T5 | 15 | 1 | 50 | 90 |
| T6 | 15 | 2 | 40 | 120 |
| T7 | 15 | 3 | 70 | 30 |
| T8 | 15 | 4 | 60 | 60 |
| T9 | 20 | 1 | 60 | 120 |
| T10 | 20 | 2 | 70 | 90 |
| T11 | 20 | 3 | 40 | 60 |
| T12 | 20 | 4 | 50 | 30 |
| T13 | 25 | 1 | 70 | 60 |
| T14 | 25 | 2 | 60 | 30 |
| T15 | 25 | 3 | 50 | 120 |
| T16 | 25 | 4 | 40 | 90 |

**Chart of Taguchi Analysis**

The lab used the exhaust method to test the formulations in Table 1 on scoured cotton garments. Weight loss, whiteness index, tensile strength, tearing strength, carboxylic group content, copper number, and residual hydrogen peroxide as a function of temperature, time, and sodium perborate and TAED concentrations are depicted in Figs. 1 and 2. Sodium perborate and TAED cause more rapid weight loss at higher doses, as shown by the general linear model analysis in Figures 1 and 2. However, the rate of weight loss slows down over time. The improved bleaching procedure results in slightly less weight loss (3.51%) than the standard bleaching process (4.63%).

Main effect plots of data mean values for tensile strength, whiteness index, and fabric weight loss due to treatment conditions are shown in Fig. 1.

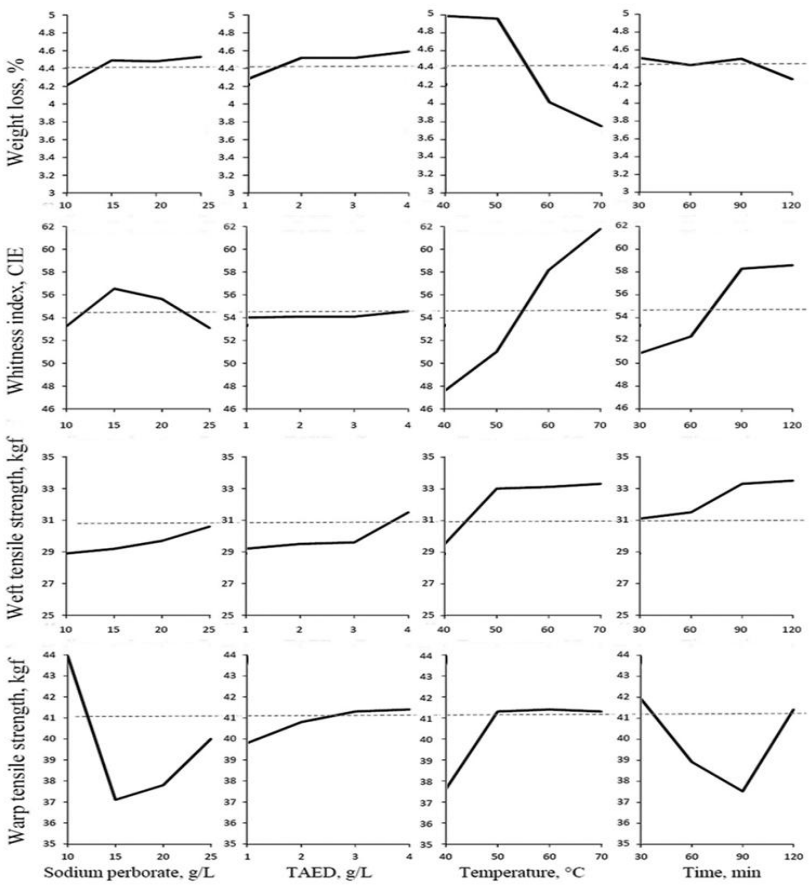
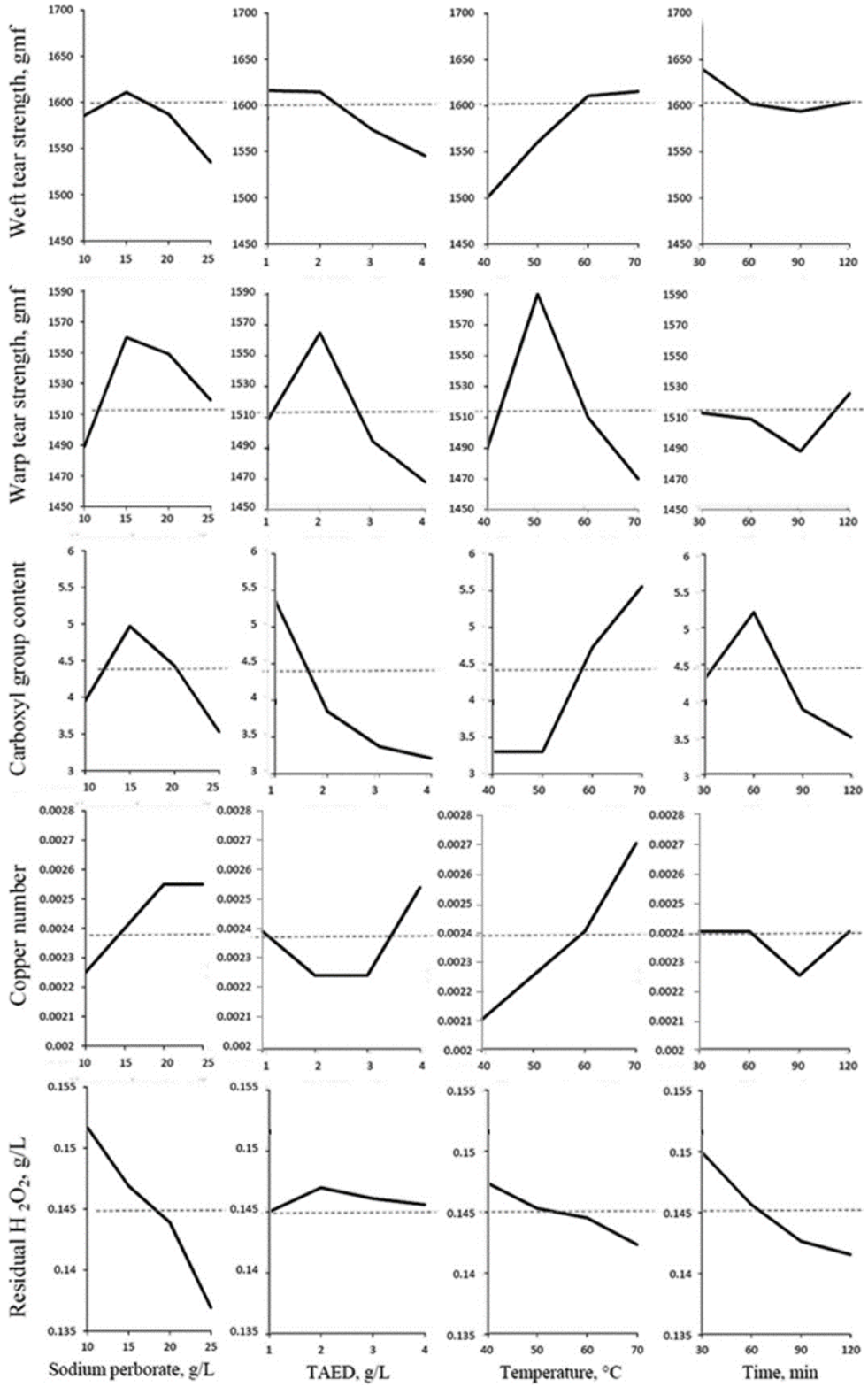



**Figure 2: Main effect plots of data for tear strength, carboxy group count, copper number, and residual peroxide of fabric, showing the influence of treatment condition.**




The tensile strength measured in the weft direction is rising across the board. Loss of weft tensile strength is reduced by roughly 10% compared to the standard bleaching method when using the modified sample.

The initial 90 minutes of a warp cause a drop in tensile strength. Treatment time and 15 g/L sodium perborate concentration, after which it rises with further increases in both variables. The relationship between TAED and temperature is insignificant. The redesigned procedure results in an 8.67% decrease in warp tensile strength loss compared to standard pre-treatment.

The proposed Method results in a 14% maximum tearing strength loss in the warp direction and an 18% loss in the weft direction. The weft way tearing strength decreases by 20% (1477.01 gmf) and the warped way by 15% (1463.38 gmf) for the traditionally treated sample. Warp-way tearing strength is substantially impacted by sodium perborate and

TAED concentrations and temperature. The loss shown increases as these variables are pushed to their extremes. Both TAED concentration and temperature have a considerable impact on the tearing strength of the weave. Weaving strength is reduced in the west as TAED concentration rises. The loss of tearing strength in both the warp and the weft is less in the new procedure compared to the traditional bleaching method.

As TAED concentration rises, carboxylic acid content falls, whereas temperature causes a rise in carboxylic acid content. Carboxyl group content is observed to be highest at 15 g/L sodium perborate concentration and 60 minutes of treatment duration and to decline after that. The improved procedure has a carboxylic group content of 4.3, which is a slight decrease from the standard bleaching process's 4.5.

The copper content increases as the sodium perborate concentration and processing temperature rise. The interaction between TAED dosage and time spent stunned is insignificant. Samples bleached using the modified procedure have a lower copper number than those bleached using the Standard Method. The commonly treated samples had a copper number of 0.003.

Sodium perborate was converted to peroxide in the bleach bath; thus, as the bath's concentration, temperature, and time were increased, less and less sodium perborate was left over. The amount of hydrogen peroxide left behind is proportional to the TAED concentration of about two g/L. Adding more TAED to the mix reduces the amount of leftover hydrogen peroxide. The typical bleaching technique leaves 18% of hydrogen peroxide behind, but this Method leaves only 5-7%.

The highest whiteness value, 61 CIE, is achieved with the T4 combination. The mixture is 57 CIE in terms of whiteness when sodium perborate is replaced with hydrogen peroxide. One possible explanation is that without a stabilizer, the peroxide in the bleach bath breaks down too quickly.

As shown in Figures 1 and 2, which display the main impact plots created by the MINITAB-13 software, the effect of sodium perborate concentration on the different results is negligible across all of the components of the tested recipes.

Taguchi's study reveals that shifts in temperature account for the total variation in results, while shifts in process time account for the least.

All of the process's influencing factors have been ranked by Taguchi analysis from most important (1) to least important (4). Time (4) > Sodium Perborate (3) > TAED (1) > Temperature (1)

The maximum degree of whiteness with the least amount of fabric degradation is the fundamental goal of any textile processing facility. This is also crucial to achieving optimal color harmony between several purchases. The best recipe for meeting the whiteness requirement was discovered to be T4 (Table 2) out of a total of 16.

Taguchi analysis reveals that the mean graph residual content reduces when the sodium perborate concentration in the bath and the length of time it is left in the water decrease. When compared to peroxide bleaching, it is slightly cheaper.

Therefore, it is suited for conducting large-scale industrial trials of the exhaust method of bleaching using a jigger.

The fabric of the same construction as that used in the laboratory trials, Greig mercerized and scoured fabric (150 kg), is bleached using the novel proposed process utilizing the optimal values of parameters, and the fabric is tested for various parameters after bleaching (Table 3). Evaluations of bleaching conducted in both the lab and on a larger scale (in the form of bulk trials) yield findings that are extremely close to those predicted by theory, with variances across the board being negligible at best. As a result, using TAED as an activator in a modified bleaching procedure, including sodium perborate, has been successful.
Sodium perborate is used as an oxidizer in the modified bleaching process, where TAED is used as an activator.

**Table 3: Results from the bulk study compared to those from the lab**

| Property | Theoretical predictions (A) | Laboratory results (B) | Difference (A-B) % | Bulk trial (C) | Difference (B-C) % |
|---|---|---|---|---|---|
| Weight loss, % | 3.71 | 3.61 | 5.39 | 3.64 | 3.70 |
| Whiteness index, CIE | 63.54 | 61 | 3.99 | 62.97 | 3.22 |
| Carboxyl content, mg/g | 3.16 | 3.46 | 9.49 | 3.32 | 4.04 |
| Residual sodium perborate, g/L | 0.16 | 0.14 | 11.42 | 0.17 | 17.65 |
| Copper number | 0.002 | 0.002 | 0 | 0.002 | 0 |
| Tensile strength loss (warp), % | 8.50 | 8.34 | 1.88 | 8.79 | 5.39 |
| Tensile strength loss (weft), % | 7.54 | 7.49 | 0.66 | 7.62 | 1.73 |
| Tearing strength loss (warp), % | 13.49 | 13.62 | 0.96 | 13.01 | 4.48 |
| Tearing strength loss (weft), % | 16.94 | 17.16 | 1.29 | 17.89 | 4.25 |

The product works just as well as regular peroxide bleaching, if not better. Maximum whiteness is observed at 70°C and two h treatment time, resulting in 55% energy and time savings and a 30% water savings improvement over conventional peroxide bleaching at 90°C for four hours. Compared to the traditional combination bleaching procedure, there is less of an impact on the environment due to the absence of sodium silicate stabilizer and fewer types of washing. Since the active species (H2O2) responsible for the bleaching action is better used in the modified procedure, the bleaching action is also improved over traditional.

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