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**ORIGINAL RESEARCH**

# Modifying Bleaching Parameters: Effects on Cotton Woven Fabric

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## Abstract

Bleaching is a pre-treatment process in the textile industry that is used to remove the natural color of grey fabric. Unsupervised variation of bleaching parameters results in improper removal of natural color, variation of whiteness and GSM, and higher energy consumption. State of the art bleaching methods analyze the effect of parameter change on cotton knit fabrics. In this study, we conducted a constructive analysis on the effects of altering significant bleaching parameters such as the amount of hydrogen peroxide (H2O2), temperature during the bleaching process, and the time required for bleaching. To conduct the experiment, we took five samples of woven cotton fabric and conducted the bleaching process in a sample dyeing machine. Hydrogen peroxide was used as the bleaching agent. We observed a gradual reduction in the fabric weight with time and when it comes to whiteness, the opposite outcome was found. A gradual increase in the concentration of H2O2 enhanced the whiteness of the fabric while reducing the weight. From our experiments, we also found that the whiteness index decreased when the fabric was bleached at lower temperature. However, the fabric loses less weight when bleached at a low temperature.

## 1 | INTRODUCTION

Textile industry holds a huge contribution in the economic field of south Asian countries such as Bangladesh, India, and Pakistan [1]. Over the years, cotton woven fabric is holding the significant portion of these economic revolution by textiles [2]. Woven cotton fabrics are popular among the consumers for their comfortability, durability, design aesthetics, handle, and drapability [3]. Bleaching is a pre-treatment process for cotton woven fabric where the natural grey color of it is removed by the application of bleaching agents such as hydrogen peroxide, sodium hypo-chloride, and so on [4]. Hydrogen peroxide is an universal bleaching agent used for natural cellulosic fibres [5]. This bleaching agent oxidizes and breaks the color producing agent, which is known as the chromophore of cotton fiber [6]. After the breaking of chromophore, the grey color disappears from the fabric surface. In the textile industry, improper setting of parameters such as temperature, concentration of bleaching agent, time in this process lead to uneven and faulty bleaching which can result in the degradation of the quality of fabric [7]. This leads to loss of profit for the manufacturers who are constantly trying to resolve this problem over the years. Since the effect of different parameters have not been properly tested in the state-of-the-art literature, industries fail to determine the proper setting of these parameters while conducting the bleaching process of cotton. Specifically, the parameter setting has been least tested in term of the woven fabric of cotton [8].

S.M. Fijul kabir et al., Observed the performance of peroxide bleaching agent with different fluorescent brightening agents to find out the whiteness impact on cotton fabric. The whiteness index was measured under D65 illuminant of spectrophotometer [9]. E. Abdel Halim proposed a redox system for bleaching of cotton fabric using sodium chlo ride/potassium permanganate with a liquor ratio of 1:10 [10]. MD. Tofazzal Hosssain et al., shows the effect of different bleaching agents on whiteness index and bursting strength of the cotton knitted fabric [11]. Xiuzhu Fei et al., designed an experiment to investigate some influential factors which affecting the performance of activated peroxide systems (APSs) to bleach cotton fabric. The screening analysis revealed that cotton substrate was the most significant factor affecting the performance of APSs on bleaching of cotton fabric, followed by T, BA, [BA], pH, PS, and [H2O2]:[BA] [12]. Tatjana Topalovic et al., used catalysed hydrogen peroxide to bleach cotton fibers at temperatures as low as 300 C by incorporating dinuclear tri-l-oxo bridged manganese (IV) complex of the ligand 1,4,7-trimethyl-1,4,7 triazacyclononane (MnTACN) as the catalyst in bleaching solution.

Bleaching was not limited to the chemical action but also affected cotton fiber capillary parameters most likely due to the removal of non-cellulosic materials as well as chain-shortened cellulose [13].

Sardag et al., proposed a combined process of enzymatic bleach clean-up, enzymatic defibrillation and dyeing on the comfort and physical properties of Tencel/cotton knitted fabrics. However, the data of their study was not conclusive due to lack of industrial data [14]. Alam et. al., proposed a postbleaching behaviors of cotton knits using reductive and oxidative bleaches [15]. Wang et. al., proposed a environmentally friendly bleaching process for cotton fabrics: mechanism and application of UV/H2O2 system [16]. Hossain et. al., conducted an investigation on the effect of different process variables on color and physical properties of viscose and cotton knitted fabrics [17]. Gideon et. al., proposed a half-bleached fabric with thermo-physiological comfort. However, in their paper effect of bleaching parameters were not discussed. [18]. Daberao et. al., proposed the effect of desizing, scouring and bleaching chemicals on the properties of the cotton fabric during pre-treatment [19]. Kabir et. al., proposed a system for bleaching of Jute-cotton blend fabric with peracetic for deep dyeing. In this paper, we conduct a series of experimentation to thoroughly study and visualize the effect of alteration of time, temperature, and concentration of bleaching agent hydrogen peroxide. To conduct this study, we go to real industrial scenario to test on industry produced fabrics in following the industry regulations. We observe a opposing effect in time and whiteness index for changing of hydrogen peroxide concentration. Although the weight of the fabric gradually reduces with the increment of the bleaching agent concentration, the whiteness increases in opposite. In terms of temperature, the whiteness index increases with higher temperature and the weight is seen decreasing at the same condition. In this paper, we make the following contribution**:**

• We identify significant existing industrial bleaching parameters to conduct our experimentation.
• We conduct our experimentation on bleaching process in two different factories.
• We provide experimental proof of our result through 10 industrial samples.
• We conduct data analysis on the data color machine for precise analysis of whiteness index with the changing of bleaching parameters.

## 2 | METHODOLOGY AND EXPERIMENT

In this section, we will discuss our experimentation in factory scenario.

### 2.1 Effect on Whiteness index

Following a general recipe, we conduct bleaching on a woven fabric of 140 grey GSM in the laboratory with Rapid EcoDyer machine. We take 5gm sample for each of our experiments. We determine the effect of bleaching with varying different parameters such as, time, temperature, and concentration on the change of whiteness index, absorbency, and loss of weight of our tested samples.

*2.1.1. Parameter: Time*

For observing the effect of bleaching time on whiteness index, following the general bleaching recipe, we take 6 bleached samples after 15 minutes keeping an interval of 1 min for each sample. Our bleaching recipe is shown in 1.

**Table 1: Bleaching Recipe**

| Chemical | Amount |
|---|---|
| **Wetting agent** | 1 gm/l |
| **Sequestering agent** | 1 gm/l |
| **Detergent** | 1 gm/l |
| **Stabilizer** | 1 gm/l |
| **Caustic soda** | 3.0 gm/l |
| **Hydrogen peroxide** | 21-23 ml/l |
| **Temperature** | 90 −100oC |
| **Time** | 15-20 Min |
| **pH** | 11 |
| **M:L** | 1:20 |
| **Sample weight** | 5 gm |

*2.1.2. Parameter: Temperature*

For observing the effect of bleaching temperature on whiteness index, following the recipe 1, we take 6 bleached samples from 90 degree Celsius with a gradient of 2 degrees for each sample.

*2.1.3. Parameter: Concentration*

To understand how varying hydrogen peroxide concentration affect the whiteness index of fabric, we vary the peroxide concentration from 21-23 ml/L. We observe the whiteness index with increment of 0.5 ml/L peroxide. We take five samples for experimentation.

### 2.2. Effect on Fabric GSM

GSM expresses the fabric weight in terms of Gram per Square Meter. On the second phase of our experimentation, we vary the time, temperature, and concentration. For measuring the Fabric GSM, we cut a sample from the fabric with the GSM cutter. The area of the sample cut by the GSM cutter is 100 cm2. We measure the sample weight in a digital balance and then multiply the value by 100 to find the fabric GSM.

*2.2.1. Parameter Time*

For observing the effect of bleaching time on Fabric GSM, following the general bleaching recipe, we take 6 bleached samples after 15 minutes keeping an interval of 1 min for each sample.

*2.2.2. Parameter: Temperature*

For observing the effect of bleaching temperature on Fabric GSM, following the recipe 1, we take 6 bleached samples from 90 degree Celsius with a gradient of 2 degrees for each sample.

*2.2.3. Parameter: Concentration*

To understand how varying hydrogen peroxide concentration affect the gram per square meter of fabric, we vary the peroxide concentration from 21-23 ml/L. We observe the white ness index with increment of 0.5 ml/L peroxide.

### 2.3. Effect on Fabric Absorbency

Absorbency is fabric's moisture and liquids retaining ability within its structure to provide comfort of skin, generation of static electricity. Moreover, it creates shrinkage, causes water repellency and enhances wrinkle recovery. To determine the fabric absorbency, we use the drop test. We measure the time in absorbing a fixed amount of distilled or deionized water by the sample. In our experimentation, we closely follow the change in fabric absorbency in terms of time, temperature, and hydrogen peroxide concentration.

*2.3.1. Parameter: Time*

For observing the effect of bleaching time on absorbency of fabric, following the general bleaching recipe, we take 6 bleached samples after 15 minutes keeping an interval of 1 min for each sample.

*2.3.2. Parameter: Temperature*

For observing the effect of bleaching temperature on absorbency, following the recipe 1, we take 6 bleached samples from 90 degree Celsius with a gradient of 2 degrees for each sample.

*2.3.3. Parameter: Concentration*

To understand how varying hydrogen peroxide concentration affect the fabric absorbency, we vary the peroxide concentration from 21-23 ml/L. We observe the whiteness index with increment of 0.5 ml/L peroxide.

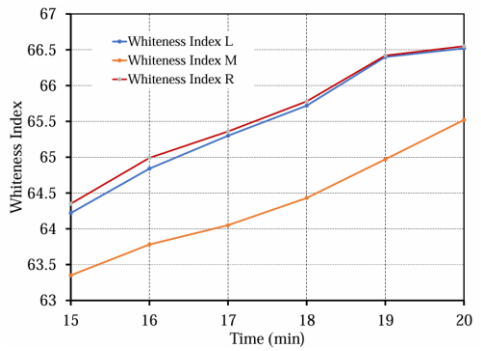


**Figure 1(a): Effect of treatment time on whiteness index**

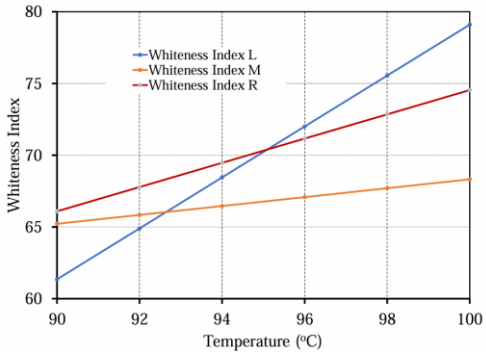


**Figure1(b): Effect of varying temperature on whiteness index**

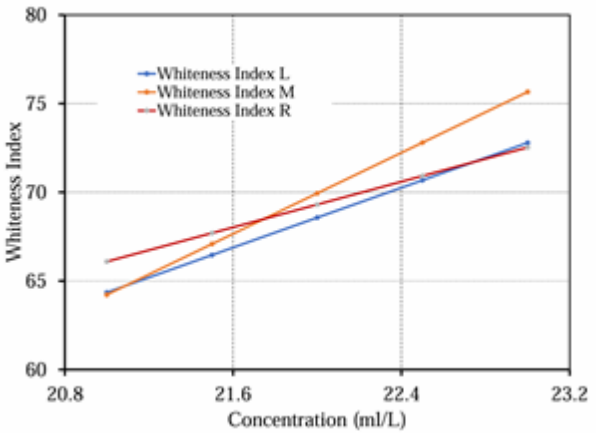


**Figure1(c) Effect of varying peroxide concentration on whiteness index**

## 3 | RESULTS AND DISCUSSION

In this section, we discuss the importance findings we got from our experimentation in the industry.

### 3.1. Whiteness Index

In our experimentation, we observed the change in the fabric's whiteness index while varying the time, temperature, and concentration of hydrogen peroxide. We measure the whiteness index in our datacolor machine on the fabric's left, right, and middle portion. In terms of time, we observe that the whiteness index gradually increases with the treatment time in bleaching. In the middle portion of fabric, the whiteness index was 64.2 on 15 minute. It slowly increased until 19 minutes. After that, the whiteness index had a modicum amount of increment to 66.5. While examining the right side of the fabric, the whiteness increased from 64.4 to 66.5. We see a slight increase in whiteness index after that. In the left side, we see that the whiteness index gradually increased without any hindrance from 63.4 to 65.5. The result is shown in Figure 1a.

In terms of temperature, we observe that the whiteness index gradually increases with the increment of temperature in bleaching. In the middle portion of fabric, the whiteness index is 65.22 on 90 degree Celsius. It slowly increases to

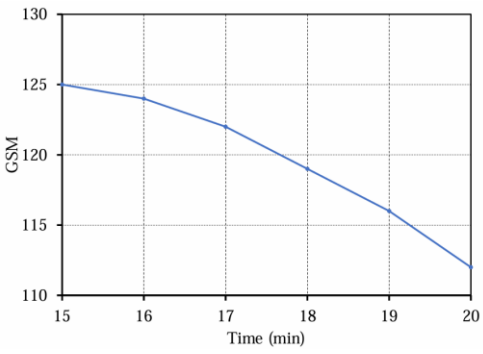


**Figure 2(a): Effect of treatment time on fabric GSM**

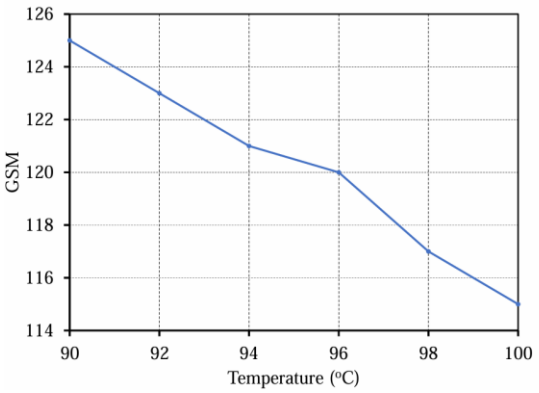


**Figure 2(b): Effect of varying temperature on fabric GSM**

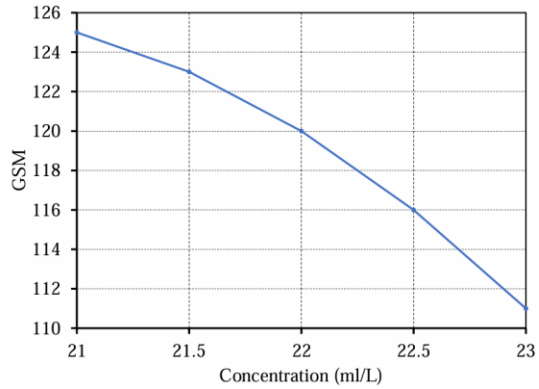


**Figure 2(c): Effect of varying peroxide concentration on fabric GSM**

68.32 on 100 degree centigrade. Examining the right side of the fabric, the whiteness significantly increases from 66.09 to 74.54. In the left side, we see that the whiteness index exponentially increasing from 61.35 to 79.1 when temperature is increased from 90 to 100 degree Celsius. The result is shown in Figure 1b.

In terms of peroxide concentration, we observe that the whiteness index gradually increases with the increment of concentration in bleaching. In the middle portion of fabric, the whiteness index was 64.22 on 21 (ml/L) peroxide concentration. It steeply increases to 75.66 on 23 (ml/L) peroxide concentration. Examining the right side of the fabric, the whiteness gradually increases from 66.09 to 72.53. In the left side, we see that the whiteness index gradually increasing from 64.35 to 72.79 when concentration is increased from 21 to 23 (ml/L). The result is shown in Figure 1c

### 3.2. Fabric GSM

We measure the fabric GSM with our GSM cutter and digital balance on the fabric's left, right, and middle portion. In terms of time, we observe that the GSM gradually decreases with the treatment time in bleaching. The result is shown in Figure 2a In terms of temperature, we observe that the GSM quickly decreases with the increment of temperature in bleaching from 90 degree Celsius to 100. The result is shown in Figure 2b In terms of peroxide concentration, we observe that the GSM gradually decreases with the increment of peroxide concentration in bleaching from 21 to 23 (ml/L). The result is shown in Figure 2c.

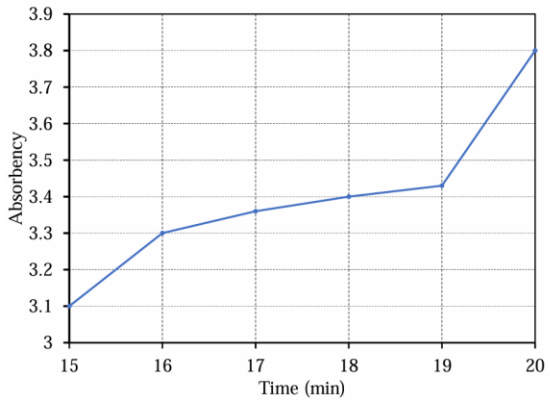


**Figure 3(a): Effect of treatment time on fabric absorbency**

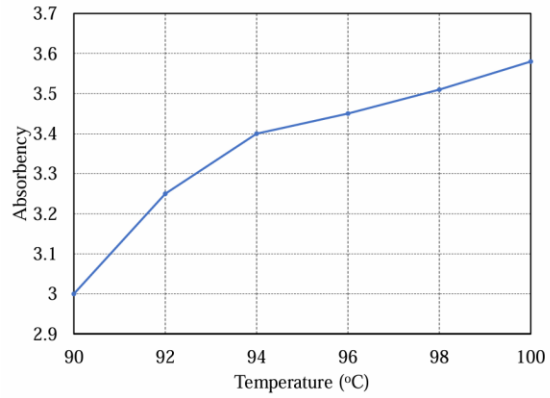


**Figure 3(b): Effect of varying temperature on fabric absorbency**

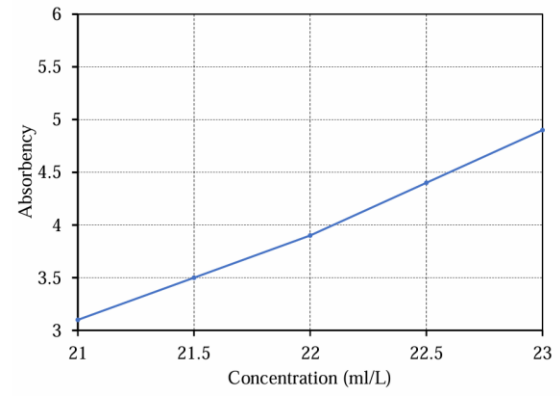


**Figure 3(c): Effect of varying peroxide concentration on fabric absorbency**

### 3.3. Absorbency

We measure the absorbency of the fabric during the bleaching treatment. In terms of time, we observe that the absorbency gradually increases with the time in bleaching from 3.1 at 15 minutes treatment time to 3.8 at 20 minutes treatment time. The result is shown in Figure 3a In terms of temperature, we observe that the absorbency quickly increases with the incre ment of temperature from 90 degree C to 100 degree C, from 3 to 3.58. The result is shown in Figure 3b In terms of peroxide concentration during the bleaching treatment, the absorbency is seen to slowly increase from 3.1 to 4.9 with the concentration of peroxide. The result is shown in Figure 3c

## 4 | CONCLUSION

In this paper, we discuss the problems related to the improper parameter setting of bleaching process and their consequences such as loss of weight of bleached fabric, production of improperly bleached fabric, and so on. State-of-the-art approaches of solving these problems do not provide the adequate remedy. Hence, in this paper, we examine the effects of varying bleaching parameters on the fabric's whiteness index, Gram per square meter of tested sample, and Absorbency. We observed altering effect of the bleaching parameter on fabric GSM and absorbency with the change of treatment time, treatment temperature, and concentration of peroxide. We also found a gradual increment of whiteness of the bleached fabric with the increasing temperature and expansion of time. In our experiment, the con centration of peroxide also effected positively on the whiteness of the bleached fabric. In the future, we intend to work on a larger amount of sample to acquire a detailed data set and find the optimum parameters to control the bleaching treatment which in terms will give us the most appropriate and favorable bleached fabric to continue with the further processes of wet processing treatments of fabric.

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