

## Accelerated Bleaching of Cotton Material with Hydrogen Peroxide

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### Abstract

Nowadays, consumers increasingly demand more environmentally friendly products. This also affects the textile industry, and thus, aspects such as control of water, energy and chemicals consumption should be taken into account in textile processes. Hydrogen peroxide ( $H_2O_2$ ) is the most widely used bleaching agent for textiles and came into use around. Hydrogen peroxide is suitable for most fibers and it can be used in a wide range of machines under different conditions. Reaction products are non-toxic and non-dangerous it is applicable in strongly alkaline medium and it requires a high temperature to give the most effective bleaching. Recent research in our laboratories has focused on the development and application of compounds that enhance the bleaching process. In this investigation in order to optimize time and temperature of bleaching process various experimentations were carried out, this study reveals that, a) an increase the temperature the rate of bleaching is increases & correspondingly reduction in process time. b) An increase in concentration of ( $H_2O_2$ ) whiteness and weight loss is increases c) Hardness of water inversely proportional to whiteness & directly proportional to weight loss. d) The concentration of peroxide stabilizer is inversely proportional to the whiteness and directly proportional to weight loss.

**Keywords:** Optimization; Time; Temperature; Hydrogen peroxide; Whiteness; Weight loss %

### Introduction

The natural fiber and fabrics even after scouring still contain naturally occurring coloring matter. This yellowish and brown discoloration may be related to flavones pigment of the cotton flower. The climate, soil, drought and frost can also cause various degrees of yellowness. Tips of leaves or stalks coming in contact with the moist ball after opening will cause dark spots and discoloration.

Discoloration may also come from dirt, dust, and insects or from harvesting or processing equipment in the form of oils and greases. The object of bleaching is to produce white fabrics by destroying the colorings matter with the help of bleaching agents with minimum degradation of the fiber [1]. The bleaching agents either oxidize or reduce the coloring matter which is washed out and whiteness thus obtained is of permanent nature. Chemical bleaching of textile fibers is further aided by addition of optical brighteners.

The later stage of twentieth century the time required for bleaching dropped steadily from months to days to hours. Now-a-days, manpower required for average plant is declined considerably and the cost of bleached finished product is also reduced.

This technical break-through will continue in the future also and will reduce the cost of bleaching further. In the present experimentation efforts were made to optimized time, temperature and concentration of hydrogen peroxide, whiteness, weight loss of substrate [2].

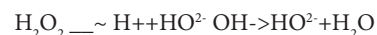
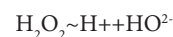
### Major objectives of investigation

1. Analyze Effects of the chemicals used in cotton bleaching process.
2. Minimized the time of bleaching process.
3. Optimize the percentages of chemicals are required for bleaching process.
4. Maximize whiteness and minimized the weight loss of bleaching process.

### Mechanism of peroxide bleaching

Though hydrogen peroxide is stable in acidic medium, but bleaching

occurs by the addition of alkali or by increased temperature. Hydrogen peroxide liberates per hydroxyl ion ( $HO^2$ ) in aqueous medium and chemically behaves like a weak dibasic acid. The per-hydroxyl is highly unstable and in the presence of oxidizable substance (coloured impurities in cotton), it is decomposed and thus bleaching action takes place. Sodium hydroxide activates hydrogen peroxide because H ion is neutralized by alkali which is favorable for liberation of  $O_2$ .



However, at higher pH (above 10.8) the liberation of  $HO^2$  ion is so rapid that it becomes unstable with the formation of oxygen gas which has no bleaching property.

If the rate of decomposition is very high, the unutilized  $HO^2$  may damage the fiber. A safe and optimum pH for cotton bleaching lies in 10.5 to 10.8 where as the rate of evolution of per hydroxyl ion is equal to the rate of consumption (for bleaching). At higher pH, hydrogen peroxide is not stable and hence a stabilizer is frequently added in the bleaching bath [3].

### Material and Method

The material of 24's count single jersey 180 gsm fabrics obtained from commercial dyeing unit PSSGL Pvt. Ltd. Shirpur. An experiment is planned to optimize time and temperature of bleaching process, the bleaching process were carried out at different dwell time by varying temperature 100°C and 110°C and analyze the whiteness and weight loss of given substrate. Laboratory base bleaching process carried out on 5 gm of fabric, keeping liquor to goods ratio 1:10. Whiteness of fabric

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analyzed under spectrophotometer and weight loss were analyzed by taking weights of substrate before and after the bleaching process [4].

Digital PH Meter: A digital pH/Temperature meter was used with a combination of glass electrode.

Whiteness Measurement: The CIE Whiteness Index value (CIE WI) was determined for the bleached fabric using AATCC Test method. The whiteness was measured using a Data color Spectra flash SF 600X with the following setting; illuminants D-65 [5].

### Following chemicals used for bleaching process

1. Hydrogen Peroxide
2. Peroxide stabilizer (*Lenapex HPST*)
3. Demineralising Agent (*Invatex SW*)
4. Caustic soda (*Sodium Hydroxide*).
5. Wetting Agent (*Perlavin EPO*).
6. Calcium Chloride.
7. Acetic Acid.
8. Sodium Silicate.

### Results and Discussions

The purpose of this study was to explore the possibility of bleaching cotton fabric by hydrogen peroxide with varying temperature and time and analyze the effects on weight loss and whiteness and to achieve an acceptable degree of whiteness (CIE whiteness index 75) with minimum loss. Standard Recipe:

Wetting agent	=	1.00 gpl
Peroxide stabilizer	=	0.25 gpl
Demineralising agent	=	0.30 gpl
Caustic soda	=	3.00 gpl
Hydrogen peroxide	=	2.00 gpl

#### Effect of process time of bleaching on whiteness and weight loss

From Figures 1,2 and Table 1 it was observed that at 100°C temperature and dwell time of process increases 10,15 and 20 minutes, the whiteness and weight loss is increases respectively but wax, impurities and natural coloring matter not completely removed from the substrate and with standard recipe at 110°C with 20 min dwell time whiteness increases and weight loss also increases. Among the all Recipes, Recipe III shows optimum whiteness and weight loss as standard. In general, the time of bleaching is inversely proportional to

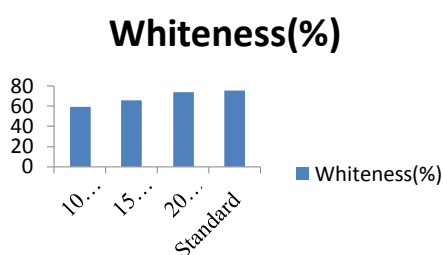


Figure 1: Effect of process time of bleaching on whiteness.

#### Weight Loss(%)

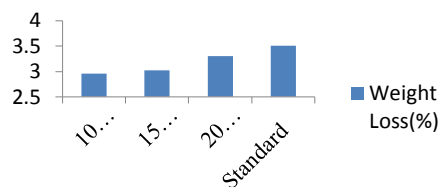


Figure 2: Effect of process time of bleaching on weight loss.

Sr No.	Parameters	Temperature	Time	Whiteness (%)	Weight Loss (%)
1.	Standard	110°C	20 minutes	75.00	3.50
2.	Standard	100°C	10 minutes	58.80	2.95
3.	Standard	100°C	15 minutes	65.40	3.02
4.	Standard	100°C	20 minutes	73.81	3.30

Table 1: Shows the effect Standard recipe varying with temperature and time for optimizing whiteness and weight loss %.

#### Whiteness(%)

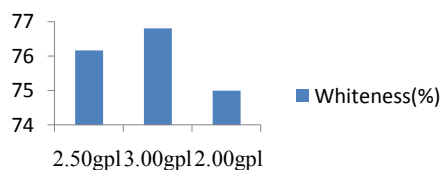


Figure 3: Effect of concentration of hydrogen peroxide on whiteness and weight loss %.

#### Weight Loss(%)

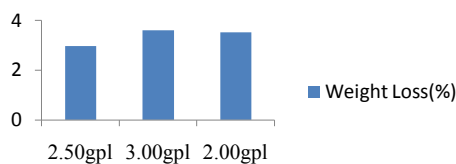


Figure 4: Effect of concentration of hydrogen peroxide on weight loss %.

the temperature of the bleaching bath [6].

#### Effect of concentration of hydrogen peroxide on whiteness and weight loss %

In order to reduce the time of bleaching process, increasing concentration of Hydrogen peroxide & analyzes the effects on given substrate and compare with standard process.

From Figures 3,4 and Tables 2,3 it was observed that, an increasing concentration of hydrogen peroxide with temperatures reducing the dwell time of the bleaching process. Whiteness and weight loss of substrate is increases. Recipe-II recorded high Whiteness & weight loss but not severe damage to the fabric. Among the all recipes with standard, Recipe-I show optimum result compare to standard. As concentration increases from 2 gpl to 2.5 gpl, 3 gpl whiteness increases and weight loss is also increases. But recipe-I recorded optimum whiteness and weight

Sr No.	Chemicals used in standard recipes	Concentration	Temperature	Time	Whiteness	Weight loss %
1	Wetting agent	1.00 gpl	110°C	20 min	75.00	3.50
2	Peroxide stabilizer	0.25 gpl	110°C	20 min		
3	Demineralising agent	0.30 gpl	110°C	20 min		
4	Caustic soda	3.00 gpl	110°C	20 min		
5	Hydrogen peroxide	2.00 gpl	110°C	20 min		

Table 2: Shows the effect of standard recipe on whiteness and weight loss %.

Sr No.	Recipes used	Concentration Of H <sub>2</sub> O <sub>2</sub> (gpl)	Temperature	Time	Whiteness (%)	Weight Loss (%)
1.	Standard	2.00	110°C	20 minutes	75.00	3.50
2.	Standard	2.50	100°C	15 minutes	76.16	2.95
3	Standard	3.00	100°C	15 minutes	76.80	3.60

Table 3: Effect of concentration of hydrogen Peroxide on whiteness and weight loss.

Sr No.	Hardness Of Water (ppm)	Whiteness (%)	Weight Loss (%)
1	20	68.54	3.50
2	50	66.39	3.60
3	100	66.63	3.70
4	200	65.39	3.80

Table 4: Effects hardness of water on whiteness and weight loss.

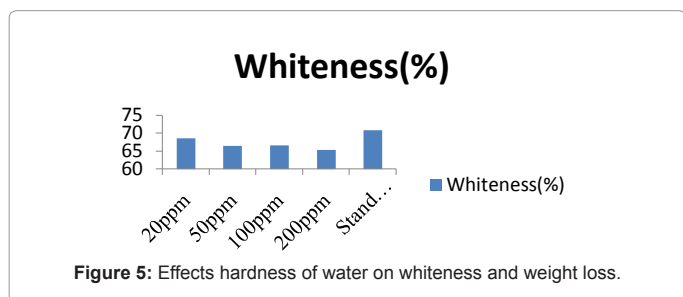


Figure 5: Effects hardness of water on whiteness and weight loss.

loss. The time required to bleach with hydrogen peroxide depends on temperature, class of fiber and equipment used for bleaching. In general, as increases the concentration of hydrogen peroxide the rate of bleaching is increases & correspondingly whiteness increases and weight loss decreases and process time reduced. At higher temperature and process dwell time increases leads to increases weight loss.

#### Effects hardness of water on whiteness and weight loss

For this experimentation, Different ppm of hard water and Standard recipes without Demineralising agent, were used, Condition used were-Temperature=100°C and Time=20 minutes and analyzing effects hardness of water on whiteness and weight loss.

From Table 4 and Figures 5,6 it was observed that When hardness of water increases 20 ppm to 200 ppm weight loss in the cotton substrate is increases and whiteness decreases. Among the all recipes 200 ppm shows high weight loss and low whiteness that is due to hardness of water increases, rate of peroxide decomposition are increases. In general it was observed that as hardness of water inversely proportional to whiteness & directly proportional to weight loss.

#### Effect of concentration of peroxide stabilizer on whiteness and weight loss keeping temperature constant and compare with standard

In this experimentation Standard recipes were used but concentration of peroxide stabilizer changed and analyzes the whiteness and weight loss.

Figures 7,8 and Table 5 it was observed that, an increasing concentration of stabilizer keeping temperature and time as constant, with increases concentration of peroxide stabilizer, from 0.20 to 0.35 gpl whiteness and weight loss of cotton substrate is increases consistently. Among all the recipes from I to V. Standard recipes show optimum whiteness and weight loss. In general, the concentration of peroxide stabilizer is directly proportional to the whiteness and weight loss.

#### Effect of concentration of peroxide stabilizer (sodium silicates) on whiteness and weight loss

For this experimentation, standard recipes were used but concentration of stabilizer changed and analyze the effect on cotton substrate Condition for all recipes-Temperature=100°C Time=20 minutes.

From Table 6 and Figures 9, 10 it was observed that Concentration Sodium Silicate stabilizer increases from 0.1gpl, 0.2 gpl and 0.3

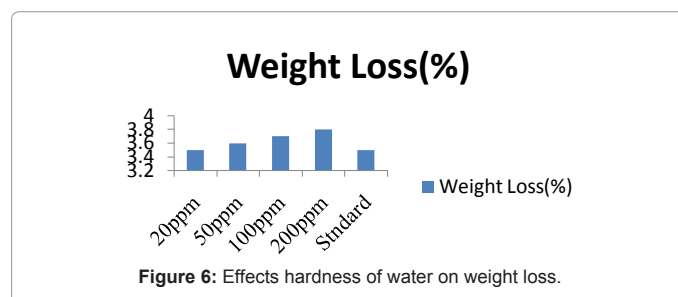


Figure 6: Effects hardness of water on weight loss.

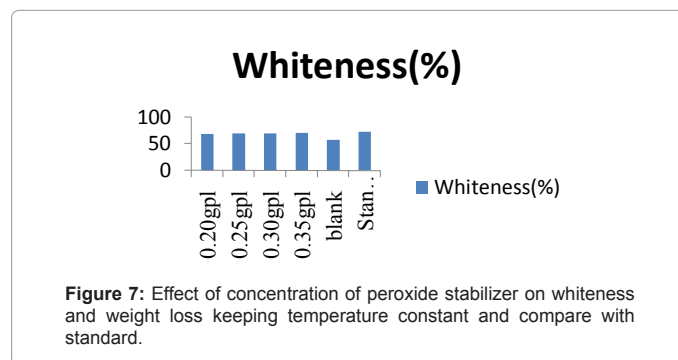


Figure 7: Effect of concentration of peroxide stabilizer on whiteness and weight loss keeping temperature constant and compare with standard.

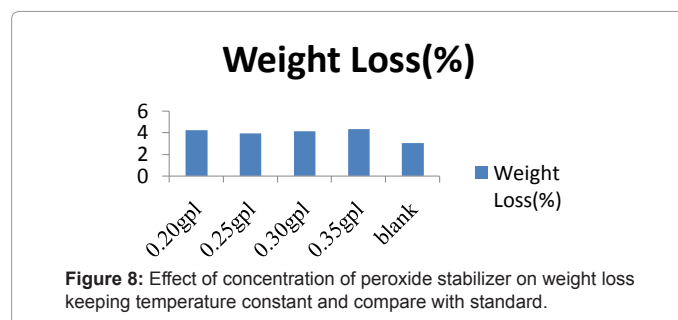


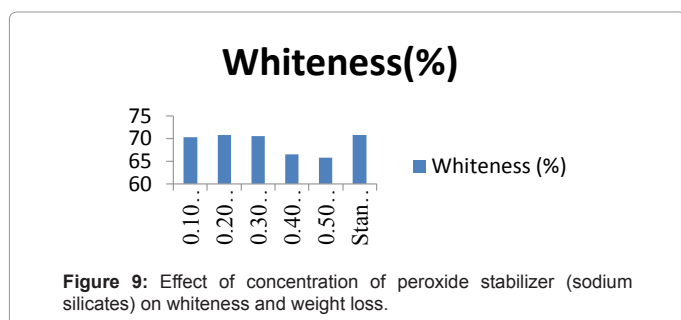
Figure 8: Effect of concentration of peroxide stabilizer on weight loss keeping temperature constant and compare with standard.

Sr No.	Parameters	Concentration Of Stabilizer (gpl)	Temperature	Time	Whiteness (%)	Weight Loss (%)
1.	Standard recipes	0.25	110°C	20 minutes	72.10	3.50
2.	I. Recipe	0.20	100°C	20 minutes	68.40	4.20
3	II. Recipe	0.25	100°C	20 minutes	68.98	3.91
4	III. Recipe	0.30	100°C	20 minutes	69.18	4.10
5	IV. Recipe	0.35	100°C	20 minutes	70.04	4.30
6	V. Recipe	0.00	100°C	20 minutes	57.44	3.00

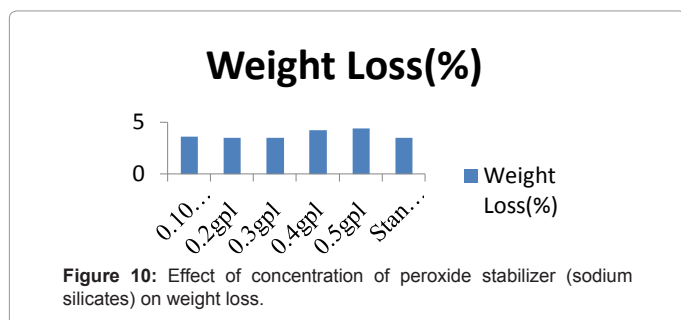
**Table 5:** Effect of concentration of Peroxide Stabilizer on whiteness and weight loss keeping temperature constant and compare with standard recipes.

Recipe No.	Concentration Of Sodium Silicate (gpl)	Whiteness (%)	Weight Loss (%)
1	0.10	70.25	3.60
2	0.20	70.76	3.50
3	0.30	70.52	3.50
4	0.40	66.46	4.20
5	0.50	65.70	4.40
Standard	0.25	70.75	3.50

**Table 6:** Effect of concentration of peroxide stabilizer (sodium silicates) on whiteness and weight loss.



**Figure 9:** Effect of concentration of peroxide stabilizer (sodium silicates) on whiteness and weight loss.



**Figure 10:** Effect of concentration of peroxide stabilizer (sodium silicates) on weight loss.

gpl whiteness is also increases but not as standard. But increase in concentration lead to increase considerable weight loss in bleaching process. Among the all recipes, standard recipes found more suitable for bleaching process.

## Conclusions

Reference to results and discussions, which refers various parameters in peroxide bleaching process, the following general variables is considered to be important while drawing the reliable conclusions on from studies.

## Effect of time of bleaching process on whiteness and weight loss

The time required to bleach with hydrogen peroxide depends on temperature, class of fiber and equipment used for bleaching. In general, the time of bleaching is inversely proportional to the temperature of the bleaching bath. As increases the temperature the rate of bleaching is increases & correspondingly reduction in process time. Recipes' no III shows the properties optimum weight loss and whiteness as compared to standard [7,8].

## Effect of concentration of hydrogen peroxide on whiteness and weight loss

The optimum concentration of hydrogen peroxide depends on number of factors namely liquor ratio, temperature and class of fiber. In general the time of bleaching is inversely proportional to the concentration of the bleaching bath. As concentration of hydrogen peroxide increases from 2 gpl to 2.5 gpl, 3 gpl whiteness increases and weight loss is also increases compared to standard. But recipe-I recorded optimum whiteness and weight loss.

## Effects of stabilizers on hydrogen peroxide bleaching

The process of regulation or control of per hydroxyl ion to prevent rapid decomposition of bleach and to minimize fiber degradation is described as stabilization. Stabilizers for peroxide normally function by controlling the formation of free radicals. In general, the concentration of peroxide stabilizer is inversely proportional to the whiteness and directly to weight loss. Sodium silicate is the most conventional, easily available and widely used stabilizer. Sodium silicate is mildly alkaline in nature. Sodium silicate forms a complex compound with per hydroxyl ions which are liberated slowly at higher temperature during bleaching process.

## Effects hardness of water on whiteness and weight loss

Among the all recipes 200 ppm shows high weight loss and low whiteness that is due to hardness of water increases, rate of peroxide decomposition are increases. In general it was observed that as hardness of water inversely proportional to whiteness and directly proportional to weight loss.

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