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# A Comparative Study on the Application of Optical Brightening Agent on Cotton Knitted Fabric in One Bath and Two Bath Exhaust Method

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**Abstract** The aim of this project work is to study on the application method of OBA on 100% cotton knitted fabric. Single jersey cotton knitted fabric (160 GSM) was treated with OBA in one bath exhaust method varying the concentration of OBA from 0.5 to 5%. The samples were then tested for determination of absorbency, whiteness index and reflectance value. From the results, it was found that the sample treated with 1.5% OBA showed better absorbency, Whiteness index and reflectance value. So, 1.5% OBA was selected as optimum OBA concentration and a number of samples were treated in two bath process in this concentration. Finally a comparison was made between the sample treated in one bath and two bath process. From the comparison, it was observed that the samples treated in two bath process showed better performances in terms of absorbency, whiteness index and reflectance value than the sample treated in one bath process.

**Keywords** CIE Whiteness Index, Direct Red, $H_2O_2$, OBA (Uvitex BLH), Scouring

## 1. Introduction

Cotton has achieved a place of pride amongst the cash crops all over the world. The unmatched beauty and comfort of cotton fabric has mainly been responsible for the spread of its cultivation in the areas of our sub-continent. It is the most pure cellulosic fabric, which contains 95-98% cellulose and lower content of lignin. Textiles, both natural and synthetics are not completely white and efforts have been made since ancient times to free them from their yellowish tinges. This yellowish tinge from fabric is generally decolorized by different bleaching methods. Whiteness in these substrates can be improved by the treatment with optical brightening agents (OBA) which intensifies the whiteness level. OBA increases the apparent reflectance of the article in the blue-violet region of the spectrum [1].

White coloring or the application of Optical Brightening Agent (OBA) is an important wet process applied to textile materials. When an optical brightening agent is applied to a textile material it absorbs the short wavelength electromagnetic radiation (300-400 nm) which is invisible to the human eye, and converts it into visible light of longer wavelength between 400 and 500 nm, which is emitted either as violet, pure blue or greenish blue. When chemically bleached cotton fabric treated with bluing agent like ultramarine blue subjected to sunlight, the bluing agent absorbs the yellowing rays of light. Consequently, when this radiation is combined with more yellowish self- color of a textile material, a brilliant white is produced [2]. Moreover waxy materials, pectin and other natural impurities of cotton cause hydrophobic properties of the raw cotton [3]. The yellowish or brown cast in cotton and other natural fibers occurs due to presence of impurities which absorbs more light in blue region of visible spectrum [4]. In general, the bleaching process removes natural colorants, water-borne stains, and oil-borne soils [5]. In colored textiles, the presence of an optical brightener or fluorescent whitening agent will intensify the colors in most of cases [6]. These brightening agents function by absorbing UV radiation and re-emitting visible light. If a UV absorber is also present in the fiber, the brightening effect from the OBA can be greatly diminished. Proper choice of an appropriate OBA can minimize this problem [7]. Though it has been found that in most cases, the presence of an optical brightener causes a decrease in the light fastness of dyed fibers [8]. Most of the bleaching agents create some adverse impact on fiber, thus the process should be accomplished with minimum of damage to the fibers being bleached. Strong and uncontrolled bleaching action can degrade the cotton fiber, thus process must be regulated carefully [9]. But the bleaching method cannot completely remove a small

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quantity of yellowness process [10]. When chemically bleached cotton fabric treated with bluing agent like ultramarine blue subjected to sunlight, the bluing agent absorbs the yellowing rays of light and the yellow residue of cotton fibers absorb some blue rays of light to almost same extend of bluing agent as well as making a balance of colors to produce a resultant lightening effect by subtractive [11, 14]. The manufactures usually apply OBA on the basis of their experience, it has not been found a compete reference of applying OBA describing all these factors while doing research by the authors.

# 2. Materials and Methods

## 2.1. Materials

Knit Fabric (Lycra Attached):

**Table 1.** Content of Knit Fabric

| Knit Fabric | Single Jersey | Yarn Count |
|---|---|---|
| GSM | 160 | 28’s |

**Table 2.** Used Machine Specification

| Name of M/C’s | Purpose | Brand Name | Model | Country of Origin |
|---|---|---|---|---|
| Sample Dyeing Machine | For Oba Treatment | MSI Rapid | L242c | China |
| Spectrophotometer | For Whiteness Measurement | Data Color | Model-600 | USA |
| PH Meter | To Measure PH | Eutch Instrument | Ecoscan | Singapore |
| IR Dryer | To Dry The Sample | Hanna | Hi 147-00 | Italy |
| Gyro Wash | Washing and Dry Cleaning | James H.Heal | 8158 | England |

## 2.2. Methods

Selection of process parameter for OBA application (Exhaust method)
For this project work we have applied exhaust method in two ways such as:

i. One bath, and
ii. Two bath

**Table 3.** Typical recipe for one bath application process

| **Chemical** | **Amount** |
|---|---|
| Wetting agent | 1 g/L |
| Sequestering agent | 2 g/L |
| NaOH | 3 g/L |
| Hydrogen peroxide | 6 g/L |
| Acetic acid | 1 g/L |
| Stabilizer | 1.5 g/L |
| Uvitex BLH | 0.5%, 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4%,4.5% ,5% |
| Fabric weight | 10 gm |
| Sample size | 10 × 10 cm |

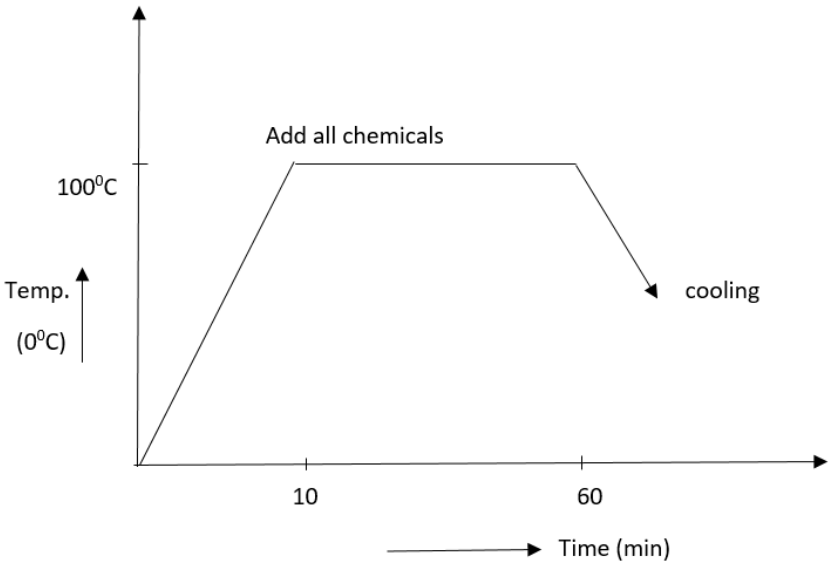


**Figure 1.** Process Diagram of One Bath Exhaust Method

2.2.1. Necessary Calculation

i. Wetting agent =(1x1000)/100=0.1 ml per sample
ii. Sequestering agent =(2x1000)/100=0.2 ml per sample
iii. NaOH =(3x1000)/100=0.3 ml per sample
iv. $H_2O_2$ =(6x1000)/100=0.6 ml per sample
v. Acetic acid =(1x1000)/100=0.1 ml per sample
vi. Stabilizer =(1.5x1000)/100=0.15 ml per sample
vii. Uvitex BLH

a. For 0.5% the required amount of OBA=(0.5x10)/100= 0.2 ml per sample
b. For 1% the required amount of OBA=(1x10)/100= 0.1 ml per sample
c. For 1.5% the required amount of OBA=(1.5x10)/100= 0.15 ml per sample
d. For 2% the required amount of OBA=(2x10)/100=0.2 ml per sample
e. For 2.5% the required amount of OBA=(2.5x10)/100= 0.25 ml per sample
f. For 3% the required amount of OBA=(3x10)/100= 0.3 ml per sample
g. For 3.5% the required amount of OBA=(3.5x10)/100= 0.35 ml per sample
h. For 4% the required amount of OBA=(4x10)/100= 0.4 ml per sample
i. For 4.5% the required amount of OBA=(4.5x10)/100= 0.45 ml per sample
j. For 5% the required amount of OBA=(5x10)/100= 0.5 ml per sample

At first cotton fabric treated with different concentration of OBA then it is found the better result of whiteness for 1.5% OBA treatment in one bath process. So, this 1.5% concentration is prepared for two bath process.

**Table 4.** Typical recipe for two bath application process

| Chemical | Amount |
|---|---|
| Wetting agent | 1 g/L |
| Sequestering agent | 2 g/L |
| NaOH | 4 g/L |
| Hydrogen peroxide | 6 g/L |
| Acetic acid | 1 g/L |
| Stabilizer | 1.5 g/L |
| Uvitex BLH | 1.5% |

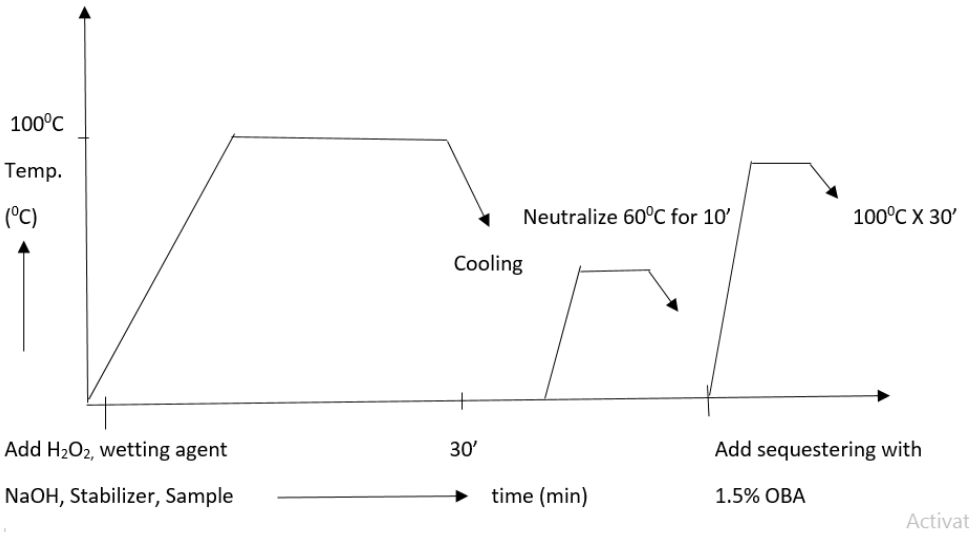


**Figure 2.** Process curve for two bath application process

2.2.2. Necessary Calculation of Two Bath Process

i. Wetting agent =(1x1000)/100=0.1 ml per sample
ii. Sequestering agent =(2x1000)/100=0.2 ml per sample
iii. NaOH =(3x1000)/100=0.3 ml per sample
iv. $H_2O_2$ =(6x1000)/100=0.6 ml per sample
v. Stabilizer =(1.5x1000)/100=0.15 ml per sample
vi. Acetic acid =(1x1000)/100=0.1 ml per sample
vii. Uvitex BLH: For 1.5% the required amount 0f OBA= (1.5x10)/100= 0.15 ml per sample.

### 2.3. Absorbency Test

In order to, determine the actual absorbency of the OBA treated knitted fabrics the following two particular absorbency test can be undertaken.

2.3.1. Wicking Test (JIS 1907 Section 7.1.5-Vertical Wicking Test)

Cut specimen in each direction, all measuring 200mm in length & 25 mm in width. Fold each specimen end & secure it on a rod or pen using a needle or a clip. Place the rod over the opening of a glass bowl, so the specimen hangs in the bowl without touching bottom. Fill the bowl with water till the specimen is immersed 20 mm in the water. Leave the specimen for 5 minutes. After 5 minutes measure how high the water has moved, starting 20 mm from the edge. For indicating the mark we use direct red solution slightly. If reaching the requirement, then stop the test.

**Standard:**

It is measured 20 mm mark point of the samples. If the result is 30- 50mm then absorbency is excellent. If value is 20 mm then absorbency is not so good. Below 20 mm, result is poor.

2.3.2. Immersion Test

Firstly cut a fabric into pieces of the size 1cm × 1cm and then put it on the water into a beaker. If the fabric is grey then it will float on water for long time but if it is well absorbed it sinks into water within 5 seconds. Higher the time taken to sink, less absorbed the fabric.

## 3. Results and Discussion

### 3.1. Whiteness Value Measurement

OBA treated knitted fabric (samples size 10 x 10 cm) displays numerous whiteness value in relation to different discrete OBA concentration. So, in order to make the fabric whiter than the whites, it is necessary to compare the whiteness value as well as the reflectance for both application process.

**Table 5.** Effect of OBA concentration on whiteness index of cotton knitted fabric treated in one bath application method

| Sample No. (10 x10 cm) | OBA Concentration (%) | Whiteness |
|---|---|---|
| Sample 1 | 0.5% | 120.16 |
| Sample 2 | 1% | 129.94 |
| Sample 3 | 1.5% | 141.84 |
| Sample 4 | 2% | 90.92 |
| Sample 5 | 2.5% | 96.13 |
| Sample 6 | 3% | 94.29 |
| Sample 7 | 3.5% | 94.59 |
| Sample 8 | 4% | 93.44 |


**Figure 3.** Whiteness varies with different OBA concentration in one bath application

From the above result, it is conferred that for 1%, 0.5%, 1.5% concentration of OBA applied sample reflectance percentage exceed over hundred. Whiteness index of the treated samples reduces differently after the concentration (1.5%) optimum because there are being created a protective blanket on sample with the increasing of concentration of OBA. The sum of the reflected light and florescence at 400-500 nm may give an effect of reflectance of different concentration of OBA applied on cotton fabric would be exceed or not exceed over the 100% reflectance.

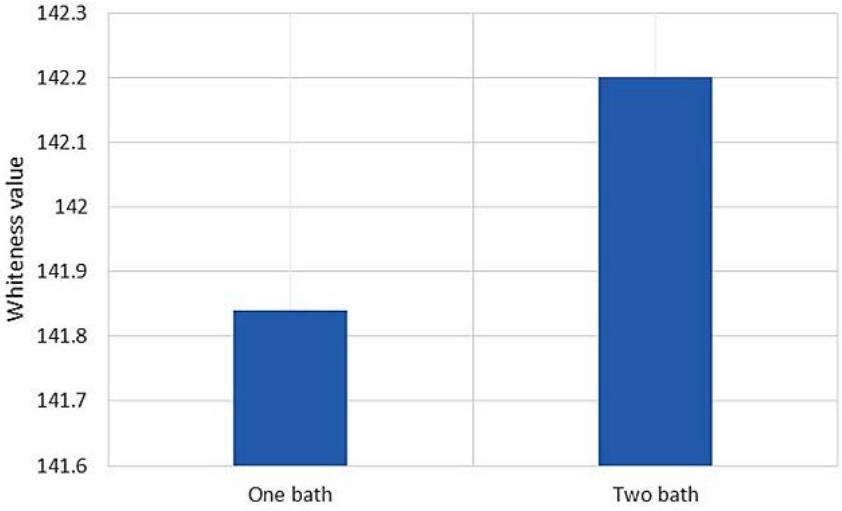


**Figure 4.** Comparative study between one bath and two bath process on whiteness index of cotton knitted fabric treated with OBA

On the contrary, when this 1.5% OBA concentration is applied for two bath process, the whiteness level of treated cotton knitted fabric is slightly escalated than the previous one bath process at a wavelength of 370 nm.

It is observed from the above test **(figure 5)** that the comparative effect of the application of OBA with 1.5% concentration on cotton knitted fabric in two bath exhaust is fairly better than one bath exhaust method. So, 1.5% concentrated OBA is used in two bath method for comparing.

### 3.2. Color Specification Value

In the Lab space, L represents the lightness (h) hue angle while a and b represents the chromaticity (c) values. The differences between the two samples of the material in the CIE Lab space is assessed as a color difference (delta), noted with ΔL, Δa, Δb [12] [13] [17]. The total difference or distance ΔE, can be computed as single value using the following formula: $\Delta E = (\Delta L^{2} + \Delta a^{2} + \Delta b^{2})^{1/2}$. The whiteness was measured using a Data color Spectra flash SF 600X with an illuminants D-65 setting [18].

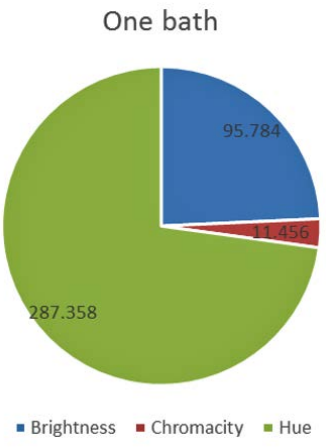


**Figure 5.** Color specification value of one bath method of OBA applied on cotton

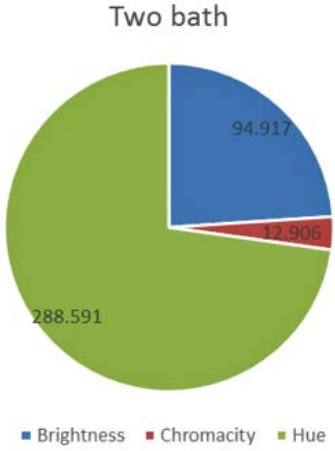


**Figure 6.** Color specification value of two bath method of OBA applied on cotton

In terms of color specification, it is observed from the **figure 6 and 7** that for one bath process the Hue (h) or lightness value is comparatively lower (287.358) than the two bath process (288.591). So, in order to make a cotton knitted fabric whiter than the whites, the best performance can be achieved if the fabric is treated at 1.5% OBA (Uvitex BLH) concentration in two bath exhaust method.

**Table 6.** Variation of color specification value of one and two bath

| Process | Brightness, (L) | Chromacity, (c) | Hue, (h) |
|---|---|---|---|
| Two bath | 94.917 | 12.906 | 288.591 |
| One bath | 95.784 | 11.456 | 287.358 |

### 3.3. Absorbency Measurement

#### a) Immersion Test:

On the other hand, similarly when we consider different OBA concentration (%) in one Bath process for the immersion absorbency test, we get better performance at 1.5% concentration of OBA.

**Table 7.** Output of Immersion Test

| Sample No. | OBA concentration (%) | Time required to sink the sample (sec) |
|---|---|---|
| Sample 1 | 0.5% | 12 |
| Sample 2 | 1% | 15.5 |
| Sample 3 | 1.5% | 6 |
| Sample 4 | 2% | Does not sink |
| Sample 5 | 2.5% | Does not sink |
| Sample 6 | 3% | Does not sink |
| Sample 7 | 3.5% | Does not sink |
| Sample 8 | 4% | Does not sink |
| Sample 9 | 4.5% | Does not sink |
| Sample 10 | 5% | Does not sink |

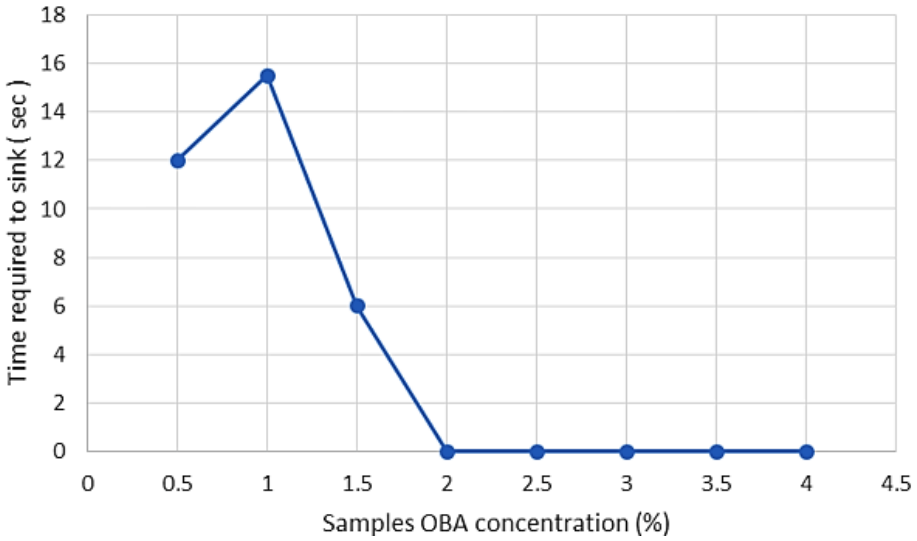


**Figure 7.** Immersion test in one bath application

Time, temperature and concentration of peroxide are all inter-related factors. At lower temperatures, longer times and higher concentrations are required. As the temperature of bleaching increases, shorter times and lower peroxide concentrations can be employed [17]. In general, the time required to sink the sample is inversely proportional to the OBA concentration (%). When the sample is treated with a maximum OBA concentration of 1.5%, it needs shorter time of 6 sec whereas for the sample 4 to 10 which are treated with different higher OBA concentration starts to plummet and finally at a certain period they does not sink properly.

From the above **(figure 4)** absorbency test result, it can be experienced that the application with 1.5% concentration of OBA on cotton knitted fabric is comparatively less time and water consuming.

**b) Wicking test:**

It is found that the examined absorbency result output variation for both one bath and two bath at 1.5% OBA concentration is as follows,

**Table 8.** Output of wicking absorbency test

| Process | Output (mm) | Remarks |
|---|---|---|
| One bath | 20 mm | Not good |
| Two bath | 60 mm | Excellent |

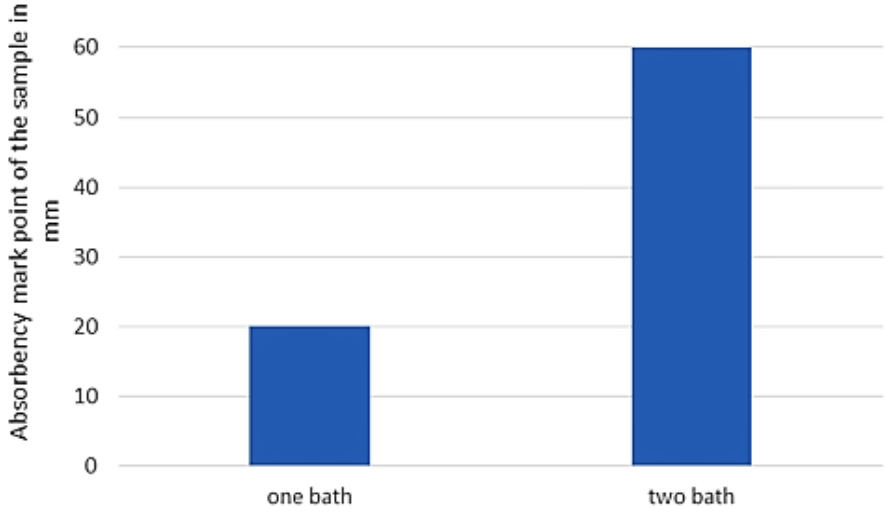


**Figure 8.** Determination of absorbency (wicking test) output at 1.5% OBA concentration both in one and two bath process

When the fabrics treated with 1.5% OBA are immersed in 20 mm water it is found that the mark point for two bath OBA treated cotton fabric exceed its mark point from 20mm to 60mm whereas one bath fabric exists with a mark point of 20mm. In this wicking test, to observe the mark point of the separate fabrics a direct red solution is added and it is found that for two bath process the output of absorbency is comparatively excellent than the one bath process.

## 4. Conclusions

The experimental data obtained in this work proved that the samples treated in two bath process showed better performance in terms of absorbency, whiteness index and reflectance value than the sample treated in one bath exhaust process. For Uvitex BLH, the optimum results were found for 1.5% concentration, 100°C temperature and 30 minutes. The yellowish tinge from fabric is generally decolorized by different OBA treatments, among them Uvitex BLH gives the cotton knitted fabric an eminent appearance which is called whiter than the whites.

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