OPTIMIZATION OF PARAMETERS OF COTTON FABRIC WHITENESS

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Abstract

In this project work, the performance of peroxide bleaching commercial bluing agent, and different fluorescent brightening on the degree of whiteness of cotton fabric was investigated and compared. Here all the experiments were done on cotton fabric; both for woven knit structures in exhausted method. Maximum whiteness is found by applying optical brightening agent of Synowhite 4KB brand of 1.2% on the weight of materials at 80^{o}C for 40 minutes treatment of cotton fabric along with salt of 5gm/L after bleaching. Furthermore, the influence of surface characteristics of the substrate on whiteness index was observed. CIE whiteness Index was measured by spectrophotometer at the standard illuminant D65.

Keywords: Scouring, Bleaching, Commercial blue, OBA, Whiteness index

Introduction:

Cotton has been found as widely used textile fibre in textile industry because of its versatile uses and properties and it is more than about 35% among all fibres used for apparel production found over the period of 2007 to 2010 (Plastina, 2011). China, U.S., Indian subcontinent consume over 55% of global cotton consumption over the period 1980 to 2008 (Seock, Y. K., Giraudo, A., & Gautreaux, L, 2013). During manufacturing (harvesting, ginning, spinning and weaving or knitting) yarn and fabric, fibres and later on yarns undergo different machines to perform different processes which contaminate fabric by adhering lubricants, such as machine oils, tars, and greases(advantageous impurities) (Hashem, 2007). Moreover waxy materials, pectin and other natural impurities of cotton cause hydrophobic properties of the raw cotton (Klug-Santner, Schnitzhofer, Vršanská, Weber, Agrawal, Nierstrasz & Guebitz, 2006). Grayish, yellowish or brownish color of cotton fibres are related to the protoplasmic residues of the protein and flavones pigments of cotton flowers (Abdel-Halim, E. S., 2012). Hence it needs to be pretreated to make the cotton fibre suitable for dyeing or any further wet-treatments. Scouring stands to remove all advantageous and natural impurities and bleaching is to make cotton made fabric pure and permanent white by removing natural coloring (grey or yellowing or brown) matters (Broadbent, A. D., & Society of dyers and colourists, 2001). The yellowish or brown cast in cotton and other natural fibres is due to presence of impurities which absorbs more light in blue region of visible spectrum (A. Nakamura, 2000). Increasing blue reflectance of the substrate by destroying the coloring matters with strong reducing or oxidizing agents is called bleaching. The function of bleaching is to remove blue-absorbing yellow contaminants (Xu, C. 2009). Cleaning is not the object of bleaching as scouring, bleaching does not remove dirt but bleaching is an oxidation process whereby coloring material is destroyed and cotton invariably is degraded (Choudhury, A. K. R. 2006). Although in dark shade this process is not compulsory but for pale and brilliant shade it is absolutely mandatory and for medium shade modified bleaching is sufficient (Zeronian, S. H., &Inglesby, M. K, 1995). This process can be done in several ways- bio-bleach or chemical bleaching (Blackburn, R. S., 2009; Aly, A. S., Moustafa, A. B., & Hebeish, A. 2004; Buschle-Diller, G., Yang, X. D., & Yamamoto, R. 2001). 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 (Zeronian, S. H., & Inglesby, M. K, 1995). Among the above processes hydrogen peroxide bleaching is widely used for the natural cellulosic fibres (cotton, flax, linen, jute) as well as protein fibres (wool, silk etc.). Hydrogen peroxide has achieved its dominant position as a bleaching agent because of its environmentally innocuousness (potentially it can decompose into oxygen and water), versatile application processes and variety of routes is available (Karmakar, S. R., 1999). But the bleaching method cannot completely remove a small quantity of yellowness process (Miljković, M. N., Purenović, M. M., Novaković, M. K., & Ranđelović, S. S., 2011). 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 fibres absorb some blue rays of light to almost same extend of bluing agent and making a balance of colors to produce a resultant lightening effect by subtractive (Plesters, J., 1993). The fluorescent brighteners (FBs) are essentially colorless fluorescent dyes used for whitening textiles process (Miljković, M. N., Purenović, M. M., Novaković, M. K., & Ranđelović, S. S., 2011). If greater degree of whiteness required to be achieved, textile material is treated with FBs which is not possible by bleaching method or applying bluing agent. The performance of FBs in terms of whiteness is developed by the absorption of light of short wavelength (which is responsible for yellow cast in fabric) i. e. ultraviolet region (330–380 nm) and the emission the light in longer wavelength i. e. visible blue light (400–450 nm) (R. Anliker, G. Müller, 1976; Shore, J. 1995; McElhone, H. J.). As optical brightening agent (OBA) works in additive process unlike bluing process and thus makes fabric more white than other whitening process (Siegrist, A. E., Eckhardt, C., Kaschig, J., & Schmidt, E. 1991). So to increase brightness, natural and synthetic textiles are treated with FBA which are designed for selective emission of blue light to give the illusion 'whiter than white' (Tiki, A., Amin, A., & Kanwal, A. 2010; Cardamone, J. M., & Marmer, W. N. 1995). In colored textiles, the presence of an optical brightener or fluorescent whitening agent will intensify the colors in most of cases (Esteves, M., A. Cyrne Noronha, and R. Marques Marinho, 2004). Though it has been found that in most cases, the presence of an optical brightener causes a decrease in the light fastness of dyed fibres (Evans, N. A., Allen, N. S., & McKellar, J. F. 1980; Shosenji, H., Gotoh, K., Watanabe, C., & Yamada, K.,1983). It reveals from the literature that for better whiteness effect, OBA application could be a solution. This paper focuses on the process optimization of OBA application and analyses the influencial parameters i. e. concentration, time, temperature, salt's amount, and fabric structures to the whiteness while applying OBA on cotton fabric. 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.

MATERIALS AND METHOD:

1. Raw material:

Knit fabric:

Knit Fabric	Single jersey	Rib	Interlock	Polo pique
Grams per Square Meter(GSM)	130	210	300	200

Woven fabric:

Woven Fabric	Plain	Matt	Twill	Sateen
Fabric Construction	$\frac{2/30 \text{ X } 20}{150 \text{ X } 95}$ X60	$\frac{20 \text{ X } 24}{72 \text{ X } 42}$ X 66	$\frac{20 \text{ X } 24}{72 \text{ X } 42}$ X 66	$\frac{20 \text{ X } 24}{72 \text{ X } 42}$ X 66
GSM	**195**	**147**	**145**	**148**

Used machine specification:

Machine Type	Machine specification
Washing machine	Trade name: Gyrowash Manufacturer: James H. Heal & Co. Ltd Origin: Halifax, England
Spectrophotometer	Manufacturer: Data color Origin: Software-USA Machine: China
Oven dryer	Trade name: Binder Manufacturer: Tuttlier Machine: Germany

2. Method

Process parameters of combined scouring &bleaching:

1. Fabric weight: X gm
2. M:L : 1:30
3. Wetting agent [Kieralan Z-bcon]: 1 g/l
4. Sequestering agent [Lufibrol MSD]: 1 g/l
5. Caustic soda [NaOH]: 1-4 g/l
6. Hydrogen peroxide [H_2O_2 (35%)]:1-4 g/l
7. Time: 40 min
8. Temperature: 90-95^{O}C

Bleaching curve:

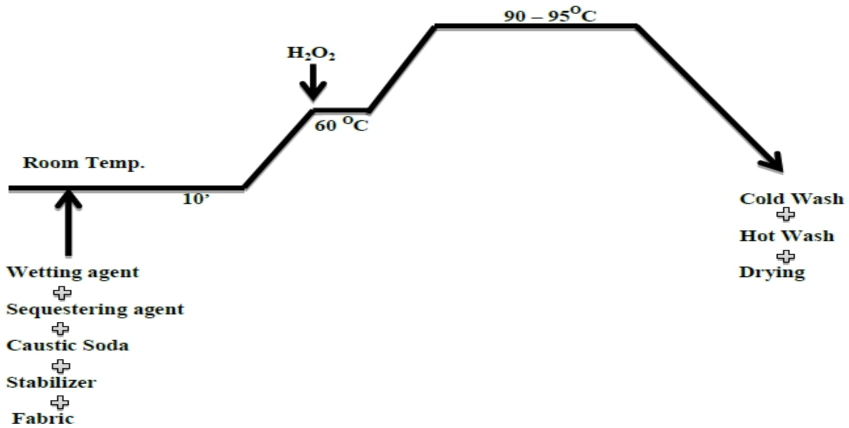


Figure-1: Process diagram of combined Scouring & Bleaching

Procedure: At first the fabric weight is taken. According to the recipe the required chemical is taken in the container of Gyro wash machine except hydrogen peroxide at room temperature. Then the bath is kept for 10 minutes. The temperature of solution rose to $60^{O}C$ and hydrogen peroxide is added to the solution. The container is placed into the Gyro wash machine and set the time and temperature. Bleaching process continued for 40-60 minute at $90\text{-}95^{o}C$. After that hot wash is given to the fabric and neutralize through acid wash with 1 g/l acetic acid. Then cold wash is given and finally drying is done.

Process parameters of application of OBA/bluing agent:

1. Fabric weight: X gm
2. M:L : 1:30
3. Wetting agent [Kieralan Z-bcon]: 1 g/l
4. OBA [Synowhite 4BK]/Commercial bluing agent: .1-2% o.w.f
5. Salt [$Na_2SO_4.10H_2O$]: 1-5g/l
6. Time: 40-60 min
7. Temperature: $60\text{-}80^{o}C$ for OBA/ $60^{0}C$ for commercial blue

OBA/Commercial blue application curve:

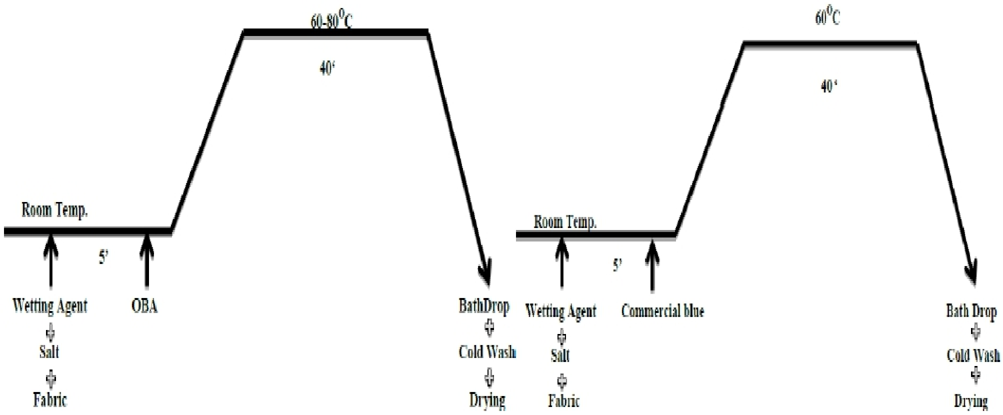
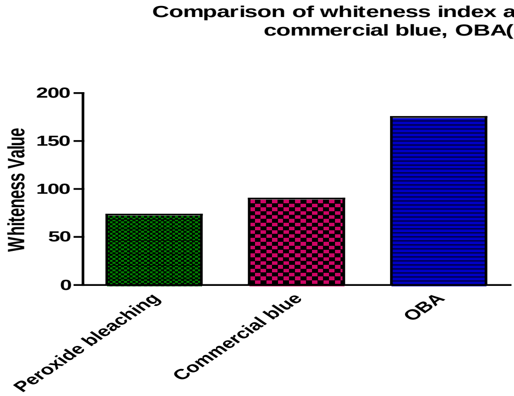


Figure-2: Process diagram of OBA/commercial blue application

Procedure:

First of all the fabric weight is taken. According to the recipe the required chemical and fabric is taken in the container of Gyro wash machine except OBA/commercial blue at room temperature .After 5 minutes we added OBA/commercial blue to the bath .Then the process is continued for 40 minute at $60\text{-}80^{o}C$for OBA/ $60^{0}C$ for commercial blue .Then cold wash is given and finally drying is done.

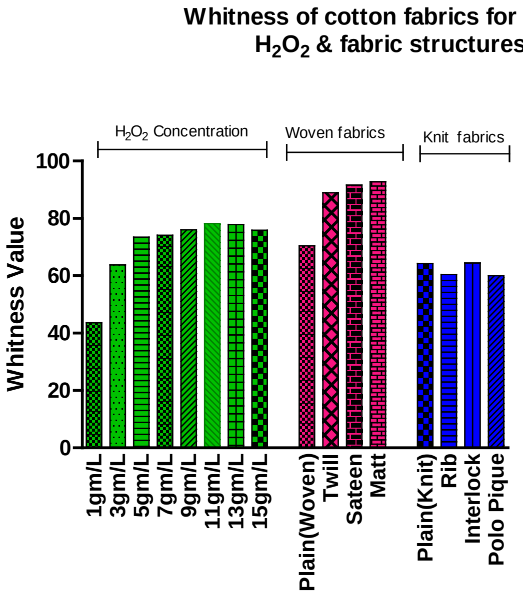
RESULTS AND DISCUSSIONS:



Recipe of applying H_2O_2	Recipe of applying Commercial blue	Recipe of applying OBA
H_2O_2(30%) :5g/l NaOH:4 g/l W.A:1 g/l S.A:1 g/l Stabilizer :1/4th of H_2O_2 Detergent :1 g/l Time:45min Temp : 95 °C	Commercial blue:1.2 % Salt:5 g/l W.A:0.5 g/l Temp:60°C Time:40 min	OBA:1.2 % Salt:5 g/l W.A:0.5 g/l Temp:60°C Time:40 min

Figure-3: Comparison of whiteness index among peroxide bleaching ,Commercial blue &OBA

It can be conferred from the above Figure -3 that OBA gives the higher whiteness index than the commercial blue and peroxide bleaching when the fabric and process parameters remain same. Here commercial blue/OBA are applied after bleaching.



Fixed Recipe for different amount of H_2O_2	Fixed Recipe for different fabric structure(woven)	Fixed Recipe for different fabric structure(knit)
Salt: 5 g/l W.A: 0.5 g/l Temp:60°C Time: 40 min	H_2O_2(30%):4 g/l NaOH:3g/l W.A. : 1 g/l S.A. :1 g/l Stabilizer: 1/4th of H_2O_2 Detergent: 1 g/l Time:45 min Temp::95°C	H_2O_2(30%):3 g/l NaOH:2 g/l W.A. : 1 g/l S.A. :1 g/l Stabilizer:1/4th of H_2O_2 Detergent:1 g/l Time : 45 min Temp : 95°C

Figure-4: Whiteness of cotton fabrics for different concentration of H_2O_2 & fabric structures

From the Figure - 4 it is seen that when we take different amount of H_2O_2 on same fabric, we get different whiteness index. If we take the concentration 1 g/l, 3 g/l, 5 g/l, 7 g/l, 9 g/l, 11 g/l, 13 g/l, and 15 g/l we find the values of whiteness index 43.59, 63.75, 73.48, 74.16, 76.05, 78.19, 77.84, 75.84 respectively. So we can say whiteness index increases with the increase of H_2O_2 concentration up to a certain limit (5g/l) and after that no remarkable improvement is occurred. So optimum result is found at 5g/l of hydrogen peroxide. Whiteness of fabric also depend on fabric structures and the graph shows in case of woven fabric matt structure show better whiteness than any other woven structures and minimum whiteness for plain structure. And in case knit structure compact structure (interlock and rib) shows better whiteness than loose structures (plain and polo pique).

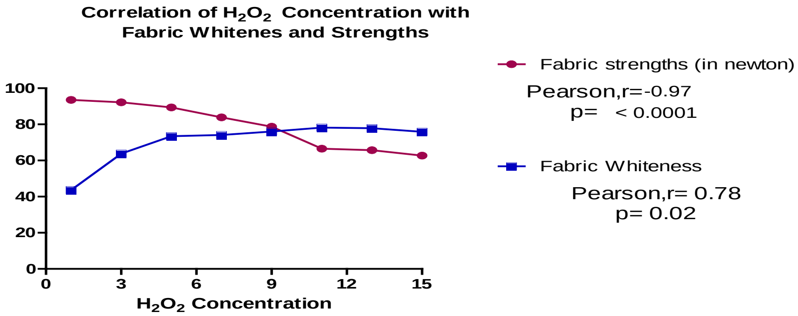
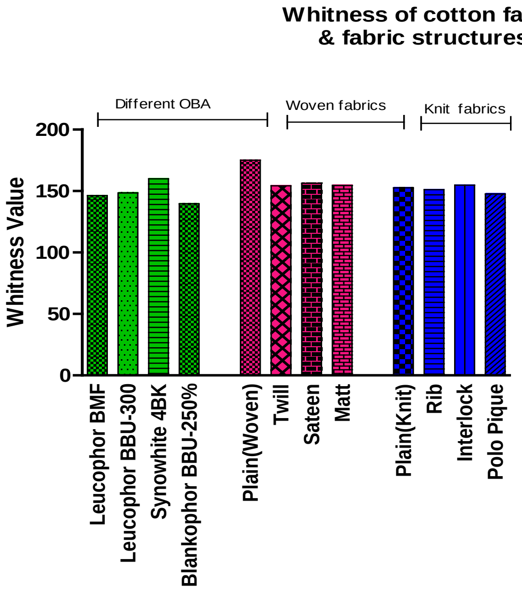


Figure-5: Correlation of H_2O_2 concentration with Fabric whiteness & strengths

From the Figure -5 it is seen that when we take different amount of H_2O_2 on the same fabric, we get different tensile strength. If we take the concentration 1 g/l, 3 g/l, 5 g/l, 7 g/l, 9 g/l, 11 g/l, 13 g/l, 15 g/l we find the values of tensile strength 935N, 922N, 894N, 839N, 787N, 665N, 657N, 627N respectively(in the graph the values have been expressed 10N=1unit). Tensile strength decreases with the increase of H_2O_2 concentration and at the same time the concentration of hydrogen peroxide contributes to the increment of whiteness value. The statistical correlation between fabric strength with hydrogen peroxide concentration is negative, found very good and significant. The statistical correlation between fabric whiteness with hydrogen peroxide concentration is positive, found good and also significant. Thus ‘bleaching has been the source of consumer dissatisfaction and compliant because of diminished wear-life’ (Carr, C. 1995).



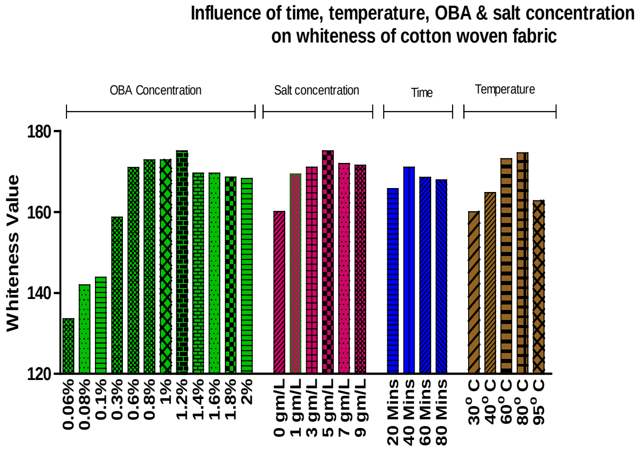
Fixed Recipe for different amount of OBA	Fixed Recipe for different fabric structures(woven)	Fixed Recipe for different fabric structures(knit)
W.A:1g/l OBA:0.2% o.w.f Glaubers Salt:5 g/l Time:40 min Temperature:60°C	Glauber Salt : 5 g/l OBA : 1.2 % W.A. : 0.5 g/l Time : 40 min Temp : 60°C	Glauber Salt : 5 g/l OBA : 1.2 % W.A. : 0.5 g/l Time : 40 min Temp : 60°C

Figure-6: Whiteness of cotton fabrics for different OBA & fabric structures

From the Figure-6 it is seen that, when we take same amount of OBA on same type of woven fabric, we get different whiteness index for different type of the OBA. Among them Synowhite 4BK gives maximum whiteness index. So we used Synowhite 4BK throughout our project.

Woven structure: The graph also explains the whiteness index of plain (1/1), matt (2/2), twill (3/1) & sateen (1/7) are 175.13, 156.23, 154.59 & 154.19 respectively. The difference varies due to the varying of the heavy & compact structure of these fabrics. Here we can conclude that plain fabric gives maximum whiteness index due to its more compact structure. It is found a noticeable variation of whiteness of different fabrics after bleaching and after OBA application which can be explained due to the variation of weight loss at pretreatment process and weight gain at dyeing process, the tendency of shrinkage of cotton fabric or due to error in result or calculation (http://urpjournals.com/tocjnls/14_13v3i1_4.pdf).

Knit structure: In interlock structure, fabric is more compact and smooth as there are no gaps between them. So interlock structures shows higher whiteness index after application of OBA. In case of plain structure face side of the fabric shows the face side of the loops but it is a relatively loose structure as all the faces loops are facing same direction. It shows better whiteness index after application of OBA. In rib structure it is found that one face loop alternate to one back loop. So there is a gap between two face loops which is responsible for less smoothness of the fabric. So the whiteness index of the rib structure is relatively low. And Polo-pique structure shows hole in the fabric surface and it is a loose structure. So the whiteness index of the polo-pique structure is very poor after application of OBA.



Fixed Recipe for different amount of OBA	Fixed Recipe for different amount of Salt	Fixed Recipe for different time duration	Fixed Recipe for different temperature
W.A. : 1 g/l S.A. :1 g/l Stabilizer:1/4th of H_2O_2 Detergent :1 g/l Time:45 min Temp:95 ° C	OBA: 1.2 % W.A: 0.5 g/l Time: 40 min Temp: 60°C	OBA:1.2 % Salt:5 g/l W.A:0.5 g/l Temp: 60°C	OBA: 1.2 % Salt: 5 g/l W.A: 0.5 g/l Time: 40 Min

Figure-7: Influence of time, temperature, OBA & salt concentration on whiteness of cotton woven fabric

The concentration of OBA has a great impact on Whiteness index. From the Figure-7 it is seen that whiteness index on the same fabric increases with the increasing of the concentration of OBA and it decreases after a certain point. It is found that at 1.2% concentration of OBA optimum whiteness is obtained. The explanation is that the maximum visual whiteness is produced with that concentration of the optical brightener on the fibre which just suffices to compensate the yellow hue of the substrate. An excess over this critical quantity can promote reflection at selective wave-length causing a deviation from white.

Most of the optical brightening agents for cellulosic fibres are markedly salt-sensitiveand salt improves the whiteness of fabric within a certain limit. From the graph it is seen that when we take same amount of OBA on the same fabric, we get different whiteness index for different amount of salt. If we take salt 0g/l, 1g/l, 3g/l, 5g/l, 7g/l, 9g/l we find the values of whiteness index 160.09, 164.81, 163.18, 174.65, 162.84 respectively. So we can say whiteness index increases with the increase of glaubers salt and after 5g/l it goes to equilibrium. But the optimum result is 5 g/l.

From the Figure-7 it is seen that when we take same amount of OBA on the same fabric, we get different whiteness index for different time. If we take the time 20 minutes, 40minutes, 60 minutes and 80 minutes, we find the values of whiteness index 165.81, 171.05, 168.57, and 167.99 respectively.

So we can say whiteness index increases with the increase of time and it goes to equilibrium after 40 minutes. But optimum result is found for 40 minutes.

From the Figure-7 it is seen that when we take same amount of OBA on the same fabric, we get different whiteness index for different temperature. If we take temperature 30^{o}C, 40^{o}C, 60^{O}C, 80^{o}C, we find the values of whiteness index 160.09, 164.81, 173.18, 174.65, 162.84 respectively. So we can say whiteness index increases with the increase of time and after 80^{o}C it decreases. But at 80^{O}C we get optimum result.

Conclusion

The experimental data obtained in this work proved that there are a certain limit for whiteness index for cotton fabric for different whitening process like bleaching, bluing and optical brightening. It is also found that OBA is the best way for getting full white cotton fabric. The results of whiteness varied with the variation of the amount of OBA, salt, time, temperature. Whiteness index also depends on the surface characteristics of the substrate. Bleaching of cotton fabric prior application of OBA helps to get the optimum results of whiteness index. For Synowhite 4BK, the optimum results were found for 1.2% o.w.f., 80°C temperature and 40 mins. 5g/l Salt helps to get the maximum exhaustion and best results of Synowhite 4BK. But the response of the fabric structure to whiteness has not been clearly understood which suggests about some research scopes as OBA was applied only for few fabric structures,only in exhausted process with improper temperature rising throughout the whole process.

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