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Research Article

Reflectance Value and Yellowing Propensity on Thermal and Storage Condition of Cotton Fabric Treated with Different Softeners

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Abstract

The aim of the research was to study the effect of different types of softeners on whiteness value and yellowing propensity by curing conditions and on storage of 100% cotton woven fabric. Different ionic nature and compositions of softeners were applied from solution to the pretreated cotton samples singly and also in combination with optical brightening agent in pad-thermofixation process to investigate the reflectance variation due to different curing temperature and time. Yellowing of fabrics on storage were also predicted by phenolic yellowing test. Different ionic nature and composition of softeners influenced the reflectance and yellowing behavior differently due to various treatment conditions.

Keywords: *Reflectance, yellowing propensity, softeners, optical brightener, curing.*

1. Introduction

Softening finishing are among the most important of textile chemical after-treatments. The hand of a fabric is a subjective sensation felt by the skin when the fabric is touched with the finger tips and gently compressed (W D Schindler *et al*, 2004). Softeners are used in every textile chemical processing industry to impart mainly soft hand and to improve some important properties to increase attractiveness and serviceability.

The softeners fall into the major classes according to the ionic nature and chemical composition such as anionic, cationic, nonionic, amphoteric, reactive and silicone (Dr. Charles Tomasino, 1992).

The yellowing of white and pastel colored textiles and garments has been a problem for many years in the textile industry. There are numerous causes that can attribute to yellowing of textiles. Most common causes are destruction, decomposition, internal change of the fiber structure due to chemical or biological degradation, aging, overheating, intensive or long term exposure to light radiation, interaction between dyes/chemicals/residues and atmospheric pollutant like nitrogen oxide, ozone, sulfur dioxide, hydrogen sulfide etc., use of phenolic antioxidant in associated products used in textile and garments industries, presence of chlorine in process water or in domestic washing, contamination by the end-users, ionic interaction of different chemicals etc. It is well known that the over use or misuse of chemical finishes such as softeners, lubricating agents, resins, optical brightening agents, or metallic salts can lead to unwanted fabric color change including fabric yellowing. (Abu Sayeed Md. Atiquzzaman *et al*,)

Basically, in all textiles (and all colours) yellowing/discolouring is possible, but it is specially visible in the very light colours, so white and pastel colours. In the darker shades you can only see the colour getting a bit duller (Chris, 2012).

Yellowing while ageing or heating can be developed for using softener especially in white textiles. Some phenolic compounds are used particularly as antioxidants in softener solution which can cause a reaction in the present of nitrogen oxides. Air pollution raises the level of nitrogen oxide in the atmosphere leading to undesired yellowness on the fabric surface (Zyschka R, 2001).

Previous researchers had studied different issues covering areas like: different softerner effects and comparative studies on different fabric properties like thermal comfortability, easy-care finishing, sewing performance, abrasion damage, color fastness, shade change and some other properties of different structure and blends of fabric. (D P Chattopadhdhyay *et al*, 2010; F Talebpour *et al*, 2006; Roqaya Sadek, 2012; M. Parvinzadeh *et al*, 2008; M Parthiban,*et al*, 2007; Mazeyar Parvinzadeh Gashti, 2007).Some studies also focused on improvement in softener production, auxiliaries in softening bath effects on finished fabric, variation on quantity of softener application in finishing etc.

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This current study focuses on study of whiteness and yellowness of fabric affected by different types of softener which are most common in use in textile industry like nonionic silicone, nonionic polyethylene and cationic amide derivatives compared to a non-treated sample as reference.

Among softeners most commonly used is the cationic and silicone softeners. All the nitrogen-based groups (amines or amides) can very well be oxidized to nitrogen oxides if the finished fabric is over heated (temperature over 140 to 150°C). Even during normal drying of the fabric/garment these groups can be oxidized and produce different oxides of nitrogen. Nitrogen oxides are brownish in color and at very low concentration they look like yellow Fig. 1 (Abu Sayeed Md. Atiquzzaman *et al*).

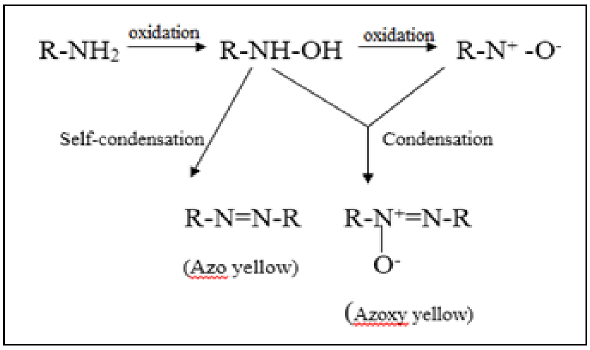

Fig. 1: Mechanism of thermo yellowing

The whiteness value and thermo yellowing propensity of the softeners treated samples were studied by the reflectance measurement using varying time and temperature of curing.

OBA (Optical Brightening Agent) is used to enhance the whiteness of the fabric. The unsaturated structure of OBA absorbs UV light and violet light at 340-370nm and it re-emits the absorbed uv light (short wavelength) in to visible blue light (longer wavelength) at 420-470nm. The emitted blue light changes the hue of the yellowness in the fabric to whiter. These unsaturations are very sensitive to sunlight and loss its ability to work & leads to yellowing (K.Senthil Kumar *et al*,)

Many optical brightening agents intensify the yellowish appearance. Additionally, some of these materials are sensitive to aging, their chemical environment, atmospheric pollutants or excessive heat. This sensitivity may cause degradation or change such that the OBA's may yellow the fabrics themselves (Rajesh Koul). The effect of different softeners on whiteness and yellowness due to curing time & temperature of OBA treated samples were studied.

A commonly occurring type of yellowing is described that typically takes the form of bright yellow patches or bands on the folded edges of nylon garments stored for long periods in cardboard boxes; it can also occur on other substrates and in other modes of storage not associated with cardboard. It can be distinguished from other types of yellowing by chemical and physical tests and is shown to be caused by the interaction of atmospheric nitrogen oxides with certain phenolic substances present in, for example, storage materials (A Litherland *et al*, 1983).

Phenolic Yellowing is discolouration of textile materials caused by the action of oxides of nitrogen and phenolic compounds, which lead to the production of a yellow colour on storage. The phenomenon of phenolic yellowing is associated with the storage of finished textile material, packed in polyethylene/aromatic polymer material or cardboard cartons (Thesmarttime). The yellowing propensity on storage of the soft finished fabrics was also studied by a simple predictive test recommended by ISO.

2. Material & Methods

2.1 Materials

2.1.1 Fabric

100% cotton woven fabrics (enzyme-desized, scoured with non-ionic detergents and bleached with hydrogen peroxide) were used for this experiment to apply different types of softening agents by padding method. The specifications of fabrics are given in Table 1.

Table 1: Fabric specifications

Parameters	Desized-Scoured-Bleached Fabric
Structure	Woven (poplin)
Composition	100% Cotton
Ends/inch	110
Picks/inch	70
Warp count	40
Weft count	40
GSM	110

2.1.2 Softening agents

Chemical Compositions and Ionic character of different softeners supplied by Orient Chem Tex Ltd. (manufactured by Jintex Corporation Ltd) are listed in Table 2.

Table 2 Different composition & Ionic nature of softener

Softeners	Commercial name	Chemical composition	Ionic nature
S1	Jinsofter EAS	amino silicone micro emulsion	non-ionic
S2	Jinlubeco PE-40	polyethylene emulsion	non-ionic
S3	Jinsofter FS Flakes (20% paste)	aliphatic amide derivatives (20% paste)	cationic

2. 2 Methods

2.2.1 Soft finishing by padding

12 pieces of bleached samples were padded by different types of softener using laboratory padding mangle of 20 gpl separately for different composition of textile softeners. After padding the samples were dried thoroughly and cured in 140 and 180 oC temperature separately for both 1min and 5 min in the laboratory dryer. The finishing bath conditions with softeners are given in Table 3.

Table 3 Soft finishing bath conditions

Concentration (gpl)	20
pH	5.5
Drying temperature, oC	110
Drying time, sec	90

Another 12 pieces of bleached samples were treated by same amount of different softeners along with 5 gpl non-ionic optical brightening agent (OBA) in the same procedure and bath conditions mentioned in Table 3. 4 pieces bleached samples were also treated by OBA without any softener as reference in the different curing conditions formerly mentioned separately.

2.2.2 Reflectance measurement

Whiteness and Yellowness evaluation

The effect of curing time and temperature on whiteness and yellowness were evaluated after applying softeners only and softeners with OBA for each sample treated at varying time and temperature conditions. The degree of Whiteness (Berger) and yellowness of the samples were measured using a datacolor spectrophotometer with 10^o observer and standard illuminant D65. All the values were measured in four different places making four folds of the samples and their average was taken for the analysis of result. The reflectance (whiteness and yellowness) values are tabulated in Table 4 and Table 5.

2.2.3 Yellowing propensity on storage

Phenolic yellowing test

Phenolic yellowing of the reference and each of the softener treated samples (at 140oC for 2 min) were tested by the standard test method ISO 105-X18 using standard phenol-impregnated test paper, control fabric, perspirometer and the standard environmental condition was provided by an incubator (50^{o}C). After removing from the incubator the intensity of yellowing were assessed by the standard Staining Grey Scale. Table 6 shows the staining results of phenolic yellowing tests.

3. Results & Discussions

3.1 Whiteness and Yellowness Index

Fig 2 & 3 represent the effect of different softeners on reflectance values whiteness and yellowness. The results indicated loss of whiteness and increase of yellowness in every case due to the effect of high temperatures and increased time in curing. Amino group has a propensity to yellowing while drying or curing hence nonionic polyethylene emulsion showed better stability to yellowing than the other two.

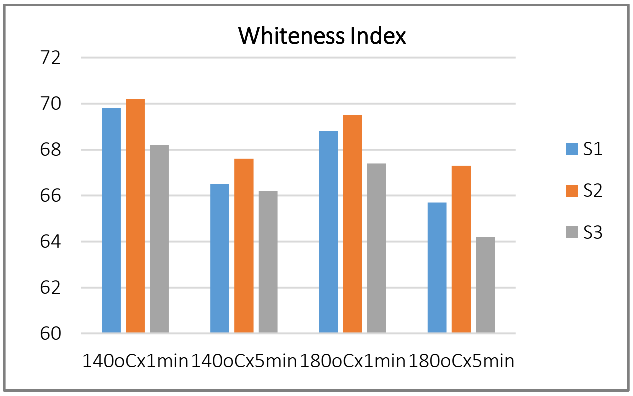

Fig 2: Effect of different softeners on Whiteness values at different treatment conditions

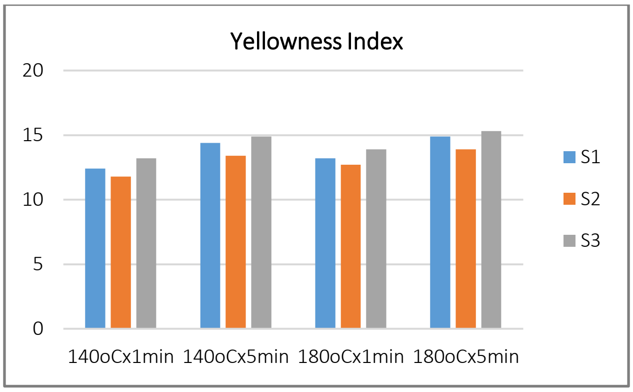

Fig 3: Effect of different softeners on Yellowness values at different treatment conditions

Table 4 Effect of different softeners on Reflectance

Softeners	Curing temp. (oC)	Curing time (min)	Whiteness Index (Berger)	Yellowness Index
Non-treated	...	...	71.9	11.2
S1	140	1 min	69.8	12.4
S2			70.2	11.8
S3			68.2	13.2
S1		5 min	66.5	14.4
S2			67.6	13.4

S3			66.2	14.9
S1	180	1 min	68.8	13.2
S2			69.5	12.7
S3			67.4	13.9
S1		5 min	65.7	14.9
S2			67.3	13.9
S3			64.2	15.3

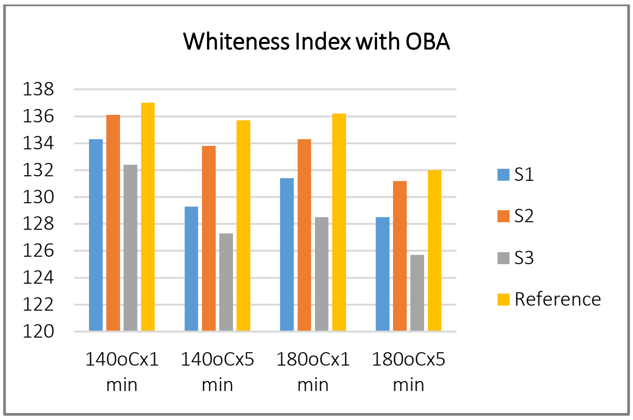

Fig.4 Effect of different softeners with OBA on Whiteness values at different treatment conditions

Fig 4 represents the whiteness values affected by softeners while applied in combination with optical brightener. Value of whiteness with optical brightener showed a reduced pattern in case of all while the cationic amide derivatives interacted the most with OBA causing the lowest value. It could be due to the interactions with cationic softener leading to deterioration of brightener. Also the pattern of the value resulted in significant change due to curing time than curing temperature.

Table 5 Effect of different softeners on Reflectance with OBA

Softener	Curing temp. (oC)	Curing time (min)	Whiteness Index (Berger)
Reference	140	1 min	137
S1			135.7
S2			136.2
S3			132
Reference	140	5 min	134.3
S1			129.3
S2			131.4
S3			128.5
Reference	180	1 min	136.1
S1			133.8
S2			134.3
S3			131.2
Reference	180	5 min	132.4
S1			127.3
S2			128.5
S3			125.7

3.2 Phenolic yellowing

The softeners on cotton fabrics showed slight yellowing propensity on storage. The amine derivatives specially the cationic softener caused comparatively slightly higher yellow stains specially while treated with OBA. It could be due to the much more action of oxides of nitrogen occurred on yellowable phenols on the cationic softener along with brightener treated samples while the polyethylene treated samples showed better stability to phenols. Results of phenolic yellowing are shown in Table 6.

Table 6: Effect of different softeners on Phenolic yellowing

Softener	Phenolic yellowing	
	without OBA	**with OBA**
Control fabric	4-5	4-5
S1	4-5	4
S2	4-5	4-5
S3	4	3-4

Conclusions

The higher degree of yellowing and reduction in whiteness caused due to the high temperature or longer time of curing in case of silicone and mostly in cationic amide derivatives treated samples which could be due to the presence of amino content having propensity to yellowing while drying or curing. The interaction between OBA and cationic softener was also found more which caused decrease in whiteness. The phenolic yellowing test of samples associated with the storage condition of textiles resulted more yellowing tendency by the application of amine based cationic softener on cotton samples. Further studies may be performed on yellowing propensity with different composition of fabric in different conditions and their possible remedies may be investigated.

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