A comparative study of Ultraviolet Protection on Treated & Untreated Denim

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Abstract - Denim garments are most preferred of today's youth. This paper represents the effect of ultraviolet protection combine with anti-ozone finish using UV absorber and anti-ozone softeners with hydrogen peroxide and sodium hypochlorite bleach on 100% cotton indigo denim to develop cost-effective protection from UV radiation. In this process, the effect of each parameter find out in this analysis where the fabric was processed with desizing, bleaching, UV Finish combines with the anti-ozone finish are discussed. Physical properties of the treated and untreated fabric that were considered in this analysis are monitored yarn count, yarn twist, yarn crimp, weave analysis, fabric count, fabric weight, fabric thickness, air permeability, cover factor, breaking strength, wash fastness, rub fastness, ozone fastness test and ultraviolet protection to analysis the effect of ultraviolet protection on treated & untreated denim.By focusing on the above said physical properties, we showed that fabric has few changes after processing in fabric thickness, fabric weight, and water repellency. Notably, the processing of fabric helped in improving the air permeability and cover factor which helps in UV protection. Moreover, it improved the breaking strength, wash fastness, rub fastness, water absorbency, ozone fastness, and UPF of the treated fabric.

IndexTerms - Ultraviolet (UV) radiation, UV transmission, Non-yellowing, Ultra Protection Factor, UV resistant finish.

I. Introduction

In recent years protection against sunlight (Ultraviolet radiation) is of high practical interest. Sunlight radiation traditionally is divided into three main regions of ultraviolet, visible and infrared. Ultraviolet radiation is dangerous for living species and other organic materials because it is characterized by the highest energy per photon which exceeds the energy of carbon–carbon single bond [Reinert G, Fuso F, Hilfiker R, Schmidt E (1997)]. High or short term exposure to ultraviolet radiation (UVR) from the sun causes sunburns and long-term exposure that leads to skin cancer.

The National Toxicology Program, U.S. Department of Health and Human Services has classified UVR as a known human carcinogen [Carcinogens listed in the tenth report]. The necessity of UV protection for the increased incidence of skin cancers is attributed due to ozone depletion. Each one percent decrease in ozone concentration is predicted to increase the rate of skin cancer by two percent to five percent [Capjack L, Kerr N, Davis S, Fedosejevs R, Hatch KL, Markee NL (1994)].

Among other protection measures recommended by dermatologists such as avoiding prolonged exposure on skin, wearing sunglasses, using cosmetics equipped with sunscreen formulations, etc. Apart from these measures, the use of UV-protected textile garments and wearing of loose-fitting and full-length clothes is one of the most important recommended measures by the World Health Organization.

Unfortunately, one cannot hold up a textile material to sunlight and determine how susceptible a textile is to UV rays. Even textiles which seem to be non-light transmitting may pass significant amounts of erythema-inducing UV irradiation [Rieker J, Guschlbauer T, Rusmich S (2001)].

Therefore, knowledge of the factors that contribute to identify the protective abilities of textiles is played vital. The important UV protective factors in textile includefiber composition, fabric construction and wet-processing history of the fabric (such as colour and other finishing chemicals that may have been applied to the textile material). In synthetic materials, it can be observed changes from their physical and mechanical properties such as fading of colour, loss of elongation and tensile strength or gloss reduction [Kaczmarek H (1996) a, b]. Therefore, the protection properties of such textiles can be successfully improved by the UV protection finishes which absorb light in the UV-B and UV-A regions (290–400nm).

Denim

Denim is a strong, durable fabric constructed in a twill weave with indigo and white yarns. The blue/indigo yarns are the lengthwise or "warp" threads (parallel to the selvage). The white yarns run across the fabric width (the weft threads). Denim is traditionally woven with 100%-cotton yarn; however, today it's blended with polyester, to control shrinkage and wrinkles, and Lycra to add stretch. Today, denim has many faces. It can be printed, striped, brushed, napped and stone washed, and the indigo. The properties of denim are that it is durable, it can stretch easily and it can hold a given shape steadily. The other properties of denim are it can be dyed using with sulphur and indigo dye. A number of technological factors have contributed to making denim the fashion icon that it is today including vast improvements in spinning, weaving, finishing etc.

Effects on denim

The effects that the consumers are looking for on their fabric. Denim has become fashionable and new techniques were developed to enhance denim garments and make them more unique.

These techniques include garment washing, stone washing, ice washing and cellulose enzyme washing. The finishing techniques which were used earlier in denim fabrics made it stiff and uncomfortable.
Normally after weaving Greige denim is singed, finished with starch and a lubricant and then mechanically shrunk. Later denim had a slightly faded appearance and a softer feel that felt so comfortable as though they had been laundered several times.
The idea of using abrasive stones was developed and stone washing was born, creating a different look on denim. Chlorine bleach was incorporated in wash techniques and new paler blue denim evolved.
Then ice washing was developed in which the porous stones are soaked in a bleaching agent. This process has been given many names, including acid wash, snow wash, white wash, frosted, etc. Recently, a cellulase wash procedure is developed in which cellular enzymes were used to accelerate colour and fibre removal.

Yellowing of denims
Yellow discolouration is very commonly seen on denims. It can develop during the processing stage, during the usage of the fabric or even with the storage of the fabric. Discolouration of the textiles mainly refers to the change of shade or loss of whiteness giving a kind of yellow tint to the fabric which is commonly known as yellowing. Discolouration of the fabric or as we say the yellowing of the fabric is very well seen on white and pastel shades. It is also affects the dark shades as the colour becomes dull and faded. Reasons of yellowing on denim are as follows:

a. **Yellowing due to softeners -** Cationic and silicone softeners are usually used for treatment of applying a softener to the fabric. Both these softeners impart a good handle to the fabric. Cationic and silicone softeners both contain primary, secondary and tertiary amines and sometimes also amides are used. All these groups also contain hydrogen group which is attached to the nitrogen atom. This is susceptible to substitution and can be replaced by chlorine to form chloramines. Chloramines are yellow in colour and impart yellowness to the fabric. The commercial detergents that are available contain the carriers of chlorine bleaches. With every wash the fabric tends to become more and yellow.

b. **Phenolic yellowing -**Storage is one of the main reasons causing phenolic yellowing. A bright yellow colour is the main feature of phenolic yellowing which also has the maximum absorption at 420- 450 nm. Clothes that we where can also be stored in poly bags. The plastic wrapping materials used in poly bags contains butylated-hydroxy-toluene (BHT) which acts as an anti-oxidant preventing it from ageing. This gets transferred on to the textile surface. BHT then reacts with the atmospheric nitrogen oxides to form nitro phenol compounds. These nitro phenol compounds are yellow in colour and impart yellowness to the fabric.

Ultraviolet radiation
Ultraviolet (UV) radiation is a component of solar radiation. UV radiation levels are influenced by a number of factors.

- Sun elevation: the higher the sun in the sky, the higher the UV radiation level.
- Latitude: the closer to the equator, the higher the UV radiation levels.
- Cloud cover: UV radiation levels are highest under cloudless skies but even with cloud cover, they can be high.
- Altitude: UV levels increase by about 5% with every 1000 metres altitude.
- Ozone: ozone absorbs some of the UV radiation from the sun. As the ozone layer is depleted, more UV radiation reaches the Earth's surface.
- Ground reflection: many surfaces reflect the sun’s rays and add to the overall UV exposure (e.g. grass, soil and water reflect less than 10% of UV radiation; fresh snow reflects up to 80%; dry beach sand reflects 15%, and sea foam reflects 25%).

Types of UV radiation: Sunlight contain three types of ultraviolet rays: UVA, UVB, and UVC.

- UVA rays cause skin aging and wrinkling, and contribute to skin cancer, such as melanoma. Because UVA rays pass effortlessly through the ozone layer (the protective layer of atmosphere, or shield, surrounding the earth), they make up the majority of our sun exposure. Beware of tanning beds because they use UVA rays to generate tanning. A UVA tan does not help protect the skin from further sun damage; it merely produces colour and a false sense of protection from the sun.
- UVB rays are also dangerous, causing sunburns, cataracts (clouding of the eye lens), immune system damage, and contributing to skin cancer. Melanoma, the most dangerous form of skin cancer, is thought to be associated with severe UVB sunburns that occur before the age of 20. Most UVB rays are absorbed by the ozone layer, but enough of these rays pass through to cause serious damage.
- UVC rays are the most dangerous, but fortunately, these rays are blocked by the ozone layer and don't reach the earth.

Sun Protection Clothing Works
There are a variety of factors:

- **Construction:** Dense, tight construction (either weaves or knits) minimizes the spaces between yarns, which in turn minimizes the amount of UV light that can pass through. Some tightly constructed UPF-rated garments use vents to boost air circulation and help the wearer stay cool. Thicker fabrics also help reduce UV transmission.
- **Dyes:** It is the specific type of dye (and the concentration in which it is used) that impacts a fabric's UV transmission, not its colour. Some dyes deflect more UV radiation than others, and some absorb none at all—including black dyes. How can one know what kind of dyes are used in individual garments? The only tip-off is if the garment carries a UPF rating. Clothing engineered for UV protection may use high concentrations of premium dyes that disrupt UV light. Such dyes include "conjugated" molecules that disrupt UV radiation. The higher the concentration of such dyes, the darker the garment becomes. But ultimately colour has no influence on UV rays. Note: Pigment-dyed fabrics, which

include a resin that creates a powdery look and feel, get high marks for UV protection.

- **Treatments:** Chemicals effective at absorbing UV light may be added during processing. Specialized laundry additives, which include optical brightening agents and newly developed UV-disrupting compounds, can boost a garment's UPF rating.
- **Fibre type:** Polyester does an excellent job of disrupting UV light (due to hydrogen- and carbon-based benzene rings within the polymer). Nylon is good. Wool and silk are moderately effective. Cotton, rayon, flax and hemp fabrics (natural fibres composed of cellulose polymers) often score low without added treatments. However, unbleached or naturally coloured cotton performs better at interacting with UV light than bleached cotton.
- **Stretch:** If a garment is stretched 10% or more beyond its normal dimensions, spaces between the yarns are widened and its effectiveness against UV light may be reduced up to 40%.
- **Wetness:** A fabric's ability to disrupt UV radiation is usually reduced when wet, though the reasons why are not completely understood. Wetness may cause a 30% to 50% reduction in a fabric's UPF rating.
- **Condition:** Worn or faded fabrics are less effective against UV light.

UV finishes on textile

All sunrays of light including visible light affect fabrics to some extent. There are two critical elements for comprehensive protection and not just UV blocking property. UV absorbers such as benzotriazole and phenyl benzotriazole, molecules are able to absorb the damaging UV rays of sunlight. UV absorbers convert UV energy in to harmless heat energy. This transformation is regenerative and can be repeated indefinitely. At the same time UV absorbers can cause discolouration, if used in higher concentrations. The construction of woven and knitted fabrics and the fibre types have a great influence on protection from ultraviolet transmittance. The ultraviolet protection factor (UPF) of textiles depends on their construction, the spaces between the yarns, their fibre types, the colour, the textile impregnation, and the presence of optical brighteners and ultraviolet absorbers. UPF also depends on the swelling capacity of the fibres. The UV blocking capacity of a fibre can be improved by incorporating TiO2 into its structure. Good skin protection, which is absolutely essential due to the accumulation of the radiation dose, is achieved by the textile itself with a sufficient weight of the fabric. In another case, e.g., light weight summer garments, a UV absorber can be applied either during fibre manufacture or in the final fabric finish which also offers the same degree of protection. Suitable organic or in organic products are also applied during this process.

By using UV absorbers, exposure of the fabric to UV lights is reduced on the one hand as well as the intensity of the transmitted UV light on the other. To indicate the protection from UV radiation the term Sun Protection Factor (SPF) is widely used. SPF is a measure of how much a sun protective crèmes protects the skin protection products. SPF is a measure of how a sun protective crèmes protects the skin from burning and is measured by timing, as to, how long skin covered with sun protective crèmes. The term Ultra Violet Protection Factor (UPF) is widely used by the textile and clothing industry.

II. LITRATURE REVIEW

2.1 Finishes

Textile finishing is the final treatment which is given to a fabric made from any kind of fibre the basic aim is to make the textile product fit for end use. A finishing process is carried out to improve inherent properties or attractiveness of the fabric and make it serviceable the term "finishing" can be explained in a wide sense as all the process which a fabric undergoes after leaving the loom or the knitting machine to that stage when it enters the market. The type of finishing treatment applied depends upon: nature of fabric, the physical properties of the fabric, end use of the material or fabric, acceptability to chemical modification and receptivity of the fabric.

Menezes E. (2009) studies on UV protective finish said that solar radiation is essential for life on earth but prolonged exposure is detrimental not only to living creatures but also paints, textiles, furniture, electronic parts.

The ultraviolet radiation can be classified in the three regions:

- UV-A – UV rays have the longest wavelengths and can penetrate in the middle layer of skin (the dermis) between the wavelength of 315-400nmare termed s UV-A. They cause skin ageing, wrinkling of the skin and in severe cases may cause skin cancer.
- UV-B – Rays between the wave length of 280-315nm are termed as UV-B and reach the outer layer of skin (epidermis). They are even more dangerous than UV-A and cause skin cancer.
- UV-C – They range in the wavelength of 100-280nm and have the shortest wavelength. They are extremely dangerous but generally do not reach the surface of the earth.

2.2 Ozone Depletion and UV Radiation

It is noticed that the ozone layer is affected by serious air pollution in recent decades. Consequently, ozone layer in the atmosphere is getting thinner and thinner. More UV radiation, especially UVB can reach the ground surface and increase the UV radiation intensity, causing harmful effects on human skin and eyes. Depletion of stratospheric ozone becomes a significant environmental and health issue in recent decades. The overuse of Chlorofluorocarbons (CFCs) is regarded as the main cause of ozone depletion (**Rom (2011**).

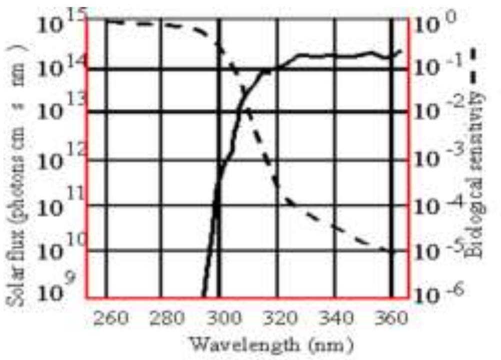
The ozone layer is located between 10 and 50 km above the earth's surface and contains 90% of all stratospheric ozone. Under normal conditions, stratospheric ozone is formed by a photochemical reaction between oxygen molecules, oxygen atoms and solar radiation. The ozone layer is essential to life on earth, as it absorbs harmful UV-B radiation from the sun. In recent years the thickness of this layer has been decreasing, leading in extreme cases to holes in the layer. With reductions being most pronounced during winter and in early spring.

The main potential consequences of this ozone layer depletion are:

- Increase in UV-b radiation at ground level: It is seen that 1% loss of ozone leads to, 2% increase in UV radiation. Continuous exposure to UV radiation affects humans, animals plants and can lead to skin problems ageing, cancer, depression of the immune system and corneal cataracts disturbance of the thermal structure of the atmosphere probably resulting in changes in atmospheric circulation.
- Reduction of the ozone greenhouse effect. Ozone is considered to be a greenhouse gas. A depleted ozone layer may partially dampen the greenhouse effect. Therefore efforts to take ozone depletion may result in increased global warming.

2.3 The Dangers of UV Radiation on Human Health

Graedel and Crutzen,(1995) founds **t**hata number of small cells damaged by UV radiation can be repaired by living species. However, excessive exposure to UV radiation is extremely harmful, e.g. causing DNA damage. The biological sensitivity (DNA damage) is shown as Plates.1. The dotted line represents the biological sensitivity in the wavelength range of 260 to 360 nm. It is found that there is a increase between the wavelength range of 320 to 300 nm. UVB is in the wavelength range of 280 to 315 nm. Therefore, UVB is regarded as a main cause of DNA damage. UVC radiation can be absorbed by the ozone layer totally. It poses small harmful effects on human beings. On the contrary, UVB radiation can reach the ground surface and penetrate deep into human cells. Therefore, UVB is more danger than UVC. UVB radiation causes health problem such as skin cancer, cataract and immune system illness.



Solar flux and biological sensitivity (Graedel and Crutzen, 1995)

Sunburn, tanning, photoaging, and skin cancer are health problems caused by UV radiation. Sunburn is caused by over exposure to UV radiation from sunlight. Typical symptoms of sunburn are red skin, swelling and irritation. In more severe cases, sunburn could take away human life. Tanning is caused by exposure of skin to UV radiation, mainly attributed by UVA. Excessive tanning can damage cells and lead to skin cancer. Photoaging is caused by continuous exposure to UVA and UVB. The main characteristic of photoaging is changes in dermis of skin, also called skin aging. Photoaging could lead to rough skin, dark spots and early wrinkles. Skin cancer is the most danger health problem caused by UV radiation. Most of the skin cancer cases are attributed by the excessive exposure to UV radiation, especially UVB. Besides, UVA and UVB can damage human DNA and immune system, they lead to cancerous changes.

All textile fibres are likely to get damaged by harmful sun rays (Svagerka (2001)). This damage mostly happens when reactions happen between light oxygen and environment influence is there textile fibres are getting affected by harmful UV radiation, the most dangerous part of sunlight Artificial sources of UV light also cause photo degradation

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2.4 UV Protection by Textiles

Saravanan (2007) deals with the deleterious effects of UV Rays and protection against them through textile materials. The best technique for reducing UV exposure is to avoid exposure, but this is an unacceptable solution to all. Recreational exposure accounts for most of the significant UVR exposures of the population, and occupational exposure is also significant. However, there is growing interest in reducing the UVR exposure of outdoor workers. The necessitates the development of stronger UV absorbers which will be especially suitable for low UPF fibres, which are highly preferred by the consumers. UVR exposure can be reduced by implementing by some change in habits such as avoiding sunlight at its maximum, using protection such as hats, sunscreens, sunglasses, and clothing.

2.5 UV **Radiation Transmission, Absorption and Reflection**

The UV radiation transmission, absorption and reflection are responsible for the UV protection ability of a fabric(Gies (2002)). They can be affected by fibre type, cover factor, dyestuff, finishing agent, stretch, wash and wear. The UV radiation transmission of fabric has been investigated by many researchers. They examined the spectral UV radiation transmission in a number of fabric types in relation to personal protection against solar UV radiation.

2.6 Influence of Fabric Parameters on UV Protection

Das (2010), The ultraviolet protection factor of the fabric is strongly dependent on the physical and chemical structure of the fibres. Natural fibres like cotton, silk and wool have a lower degree of absorption of ultraviolet radiation than synthetic fibres. Darker coloured fabrics can offer more protection than lighter coloured fabrics for the same fabric structure and dye. Optical brightening agent can improve the UPF of cotton and cotton blends, but not of fabrics that are 100% polyester or nylon. The ultraviolet protection factor of wet garment is significantly lower than that of the same garment measured in the dry state.
Stankovic et al., (2009)investigated the influence of yarn twist and surface geometry on these properties of fabrics. The grey-state plain cotton knitted fabrics were produced from yarn differing in twist level under controlled conditions, so as to obtain as similar as possible construction of the fabrics.Results obtained indicated that yarn twist to a great extent influenced the UV protection properties of the knitted fabrics through the influenced on yarn compactness and surface properties, which in turn influenced the open porosity of the fabric.

2.6 Cotton or Denim pre-treatment

D'Souza S. and Dedhia E. (2013)focuses on alternating the use of the harmful sodium Hypochlorite bleach to more organic product Lava®Jean FO in order to bleach denims. The treated and untreated fabrics were compared by testing them for fibre identification, bend analysis, tensile strength, rub fastness, spry test drop absorbency, GSM, Wash fastness, whiteness. The results showed that the properties of samples treated with Lava®Jean FO + SODA Ash and Lava®Jean FO+ Hydrogen peroxide proved to be better even at low grams per litter than sodium Hypochlorite.

III. EXPERIMENTAL METHODS, RESULTS, AND ANALYSIS

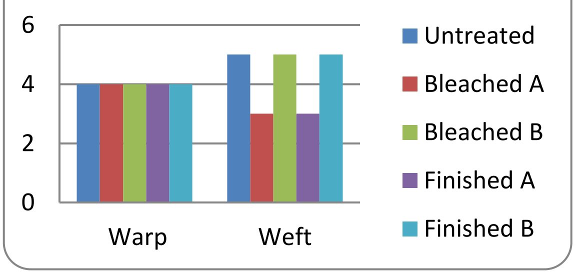
3.1 Materials and Methods

In this study, 2×1 twill weave with indigo and white 100% cotton yarns constructed fabric that is indigo denim was used. Tests conducted before treatments of the fabric were Yarn count, Yarn crimp (ASTM d3883 - 04(2012)), Yarn twist(ASTM d1422 / d1422m – 13), Fabric Thickness(standard test is-7702-1975), Air Permeability(standard test ASTM d737-96), Fabric weight (ASTM d 3776/d 377m-09ae1, standard test method for mass per unit area (weight) of fabric.), Fabric count (ASTM d 3775-08, standard test method for fabric count of woven fabric), Whiteness Index (ATCC test method 110-2011), Breaking strength(TS EN ISO 13934-1, standards test method for woven fabric tensile strength and elongation of the fabric), Ultra protective factor (AATCC test method 183-2004), Water repellence (AATCC test method 22-2010), Rub fastness (ISO 105, BS 1006, AATCC 8, BS en 20105), Wash fastness (AATCC test method 61-2010, colour fastness to laundering), Water absorbency (drop test (AATCC/ASTM test method ts-018)), Cloth cover factor and Colour fastness to ozone(ATCC test method 109-2011).
Fabric was bio-washed with enzyme (NBG) at the temperature of 60˚C for 15 minutes. As well as they were bleached with hydrogen peroxide for 60 minutes at 75˚c - 80˚c and pH maintained at 8.5 to 9, it was neutralized. Also fabric bleached with sodium hypochlorite for 60 minutes at room temperature as well as. Then were finished with UV protection (Sera fast PAPS) at 50˚C to 60˚C for 10 minutes then anti-ozone softener (Lava jean PRO) was applied with the pH of 4.5 to 5 at room temperature for 20 minutes. All tests which had been carried for untreated sample were also done on bleached and UV finished sample. All tests which had been carried on untreated sample, bleached sample and UV finished sample of Denim were compared and contrasted.

3.2 Results and discussion

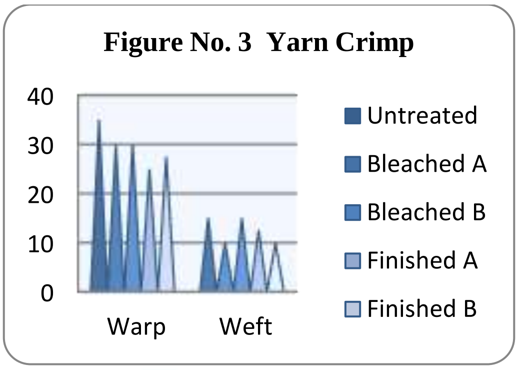
The microscopic view of this sample showed a uniform diameter with much striations running parallel to the fibre axis. In longitudinal view fibre had a cylindrical swollen structure with convolutions and an appeared fibre collapsed spirally twisted tubes with a rough surface with flat, twisted, ribbons like with canal a wide enough called lumen and has a granular effect.
In Cross sectional view fibre has a unique cross section. It appears as a single cell with exceedingly complex structure. The lumen is seen clearly. In the burning test it was seen some fibres scorched and ignited readily. These fibres burned with yellow flame giving out a smell of burning paper and formed a light feathery ash. In solubility test, fibres dissolved in a concentrated acid while some fibres got swollen in concentrated alkali. In concentrated H_2SO_4 fibres dissolved and showed change in colour. This indicates that the fibre was cellulosic group that is "Cotton". In indigo test fibres are dissolved in Dimethylformamide (DMF) for half an hour. Then residue was removed, it was seen that residue turned to white. This indicated that the fibre was 100% indigo denim. Thereby the results obtained from the microscopic, burning, solubility test, indigo test and fabric analysis it was determined that the fabric was a 100% cotton Denim.

Figure No. 2 Yarn Count



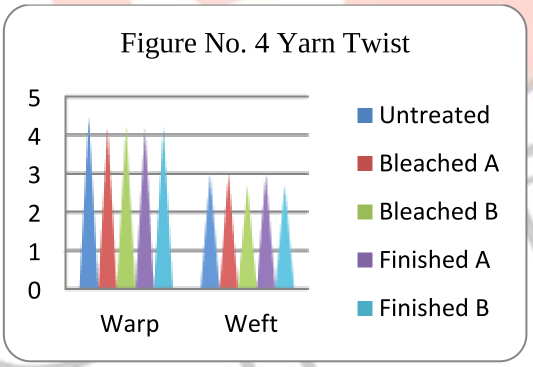
3.2.1 Yarn Count

It can be seen the fabric has a yarn count of 4 and 5 respectively in warp and weft. After bleached and UV finish application the yarn count marginally changed. In the entire sample warp ways, it was constant whereas in weft ways it was reduced in Bleached A (Hydrogen peroxide) and Finished A (UV finish)



3.2.2 Yarn Crimp

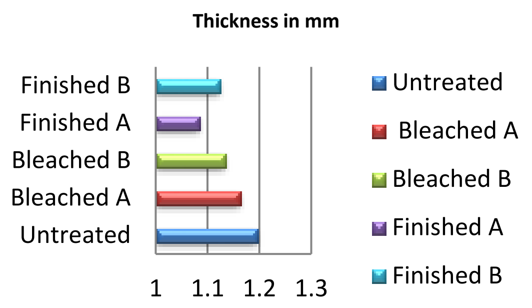
Due to the Interlacing of warp and weft a certain amount of waviness is imparted to the warp and weft threads in a fabric, this imparts crimp to the yarn. The yarn crimp was determined for the given test fabric, after bleaching and the finish application. It can be seen that the yarn crimp reading showed 35 % in warp whereas 15 % in weft, it was changed after bleaching and UV finish application. However it was noted that after bleaching with Hydrogen peroxide (Bleached A) 30% and 10 % respectively. A change was also noted bleaching with Sodium Hypochlorite (Bleached A) 30% and 15 % respectively. A marginal change was seen in after UV finish, the reading reduces by 25% to 10 %.



3.2.3 Yarn Twist

The results of the yarn twist evaluation indicated that the yarn twist direction of yarn for both warp and weft samples were same that is "S" twist. It can be seen that the yarn properties like yarn count, yarn twist and yarn crimp are good and no significant difference was observed in their values after bleaching and post application of UV finish.

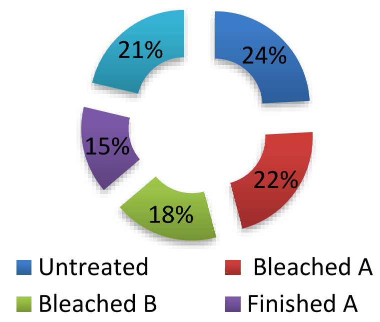
Figure No. 5 Fabric Thickness



3.2.4 Fabric Thickness

The fabric thickness was highest in the untreated sample and lowest in the Finished A sample. After the bleaching and application of UV finish, change was seen. The fabric thickness of UV treated was affected marginally**.**

Figure No. 6 Air Permeability



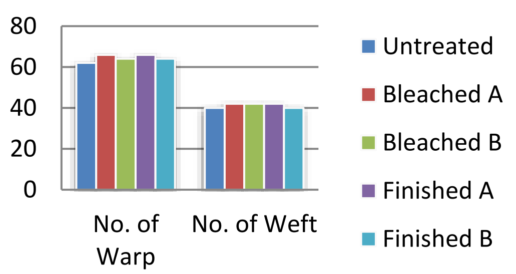
3.2.5 Air Permeability

It is an important parameter to evaluate the performance of the denim. The untreated, both bleached and treated UV finished fabric showed marginal differences in air permeability reading seen in the figure no. 6. Due to removal of starch, it shrunk and become more compact which was reduced the air permeability of the treated sample. Decreased in the air permeability increases in the UV protection of the fabric and vice- versa. The least air permeability test was seen in Finished A fabric.

3.2.6 Fabric count

The untreated denim fabric has a fabric count of 62 and 40 respectively. It was observed that there was a marginal change after Bleaching A (hydrogen peroxide), Bleaching B (Sodium Hypochlorite), Finish A (hydrogen peroxide with UV finish), and B (Sodium Hypochlorite with UV finish). Due to shrunk, it became more compact that's why the fabric count of all treated was increased.

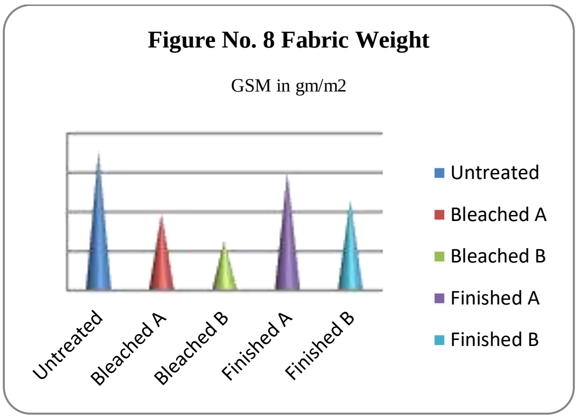
Figure No. 7 Fabric Count



seen in

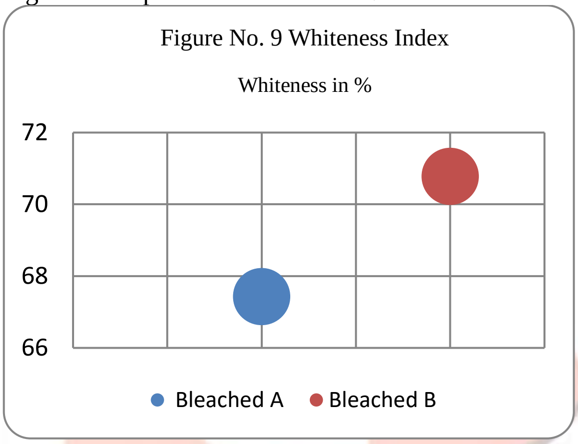
Finish

fabric



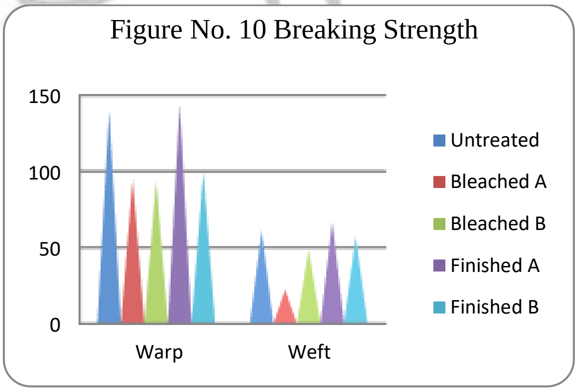
3.2.7 Fabric Weight

It can be seen that the untreated sample fabric weight is more than treated sample. Due to preparatory processes it was observed that there is an increase in moisture regain value and starch was removed from the treated samples. However, it was noted that after bleaching it decreased 199.64gm/m2 to 192.69 gm./m2 and it had increased of UV finish 203.11gm./m2 to 210.05 gm./m2 in bleaching and increase after finishing due to deposition of chemicals.



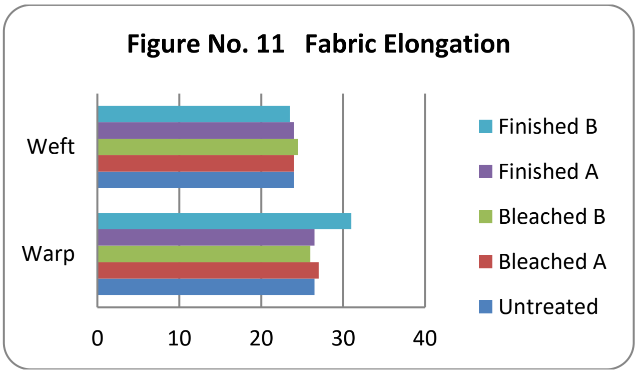
3.2.8 Whiteness Index

The increase in whiteness index from untreated denim to sodium Hypochlorite bleached was higher than bleach with Hydrogen Peroxide. It is also observed that in sodium Hypochlorite bleach, fabric increase in whiteness index is maximum that is 70.78 %, followed by peroxide bleach 67.43 %

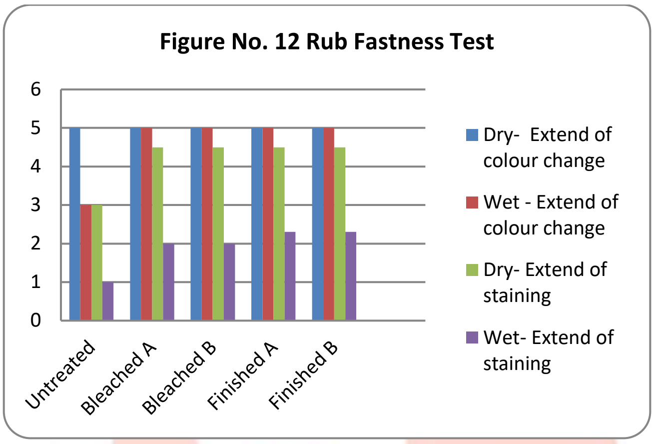


3.2.9 Breaking Strength of Fabric

The tensile strength of the untreated fabric, both bleached fabric and UV finished had a drastic variation. However, after bleaching the values reduced from 100 and 49 respectively. After UV finish change in tensile strength has been seen by improved in bleached with Hydrogen peroxide by 144 and 67 whereas reduced in Sodium Hypochlorite.



Elongation of the untreated fabric, both bleached fabric and UV finished has variation in warp from 26 to 31 cm. whereas in weft it ranges from 23.5 to 24.5cms. Higher elongation is seen in warp in finished B sample i.e. 31cm and followed by bleached A, finished A and lastly bleached B by 26 cm. In weft it was seen increase in elongation by 24.5 cm in Bleached B and reduced in Finished B by 23.5cm.

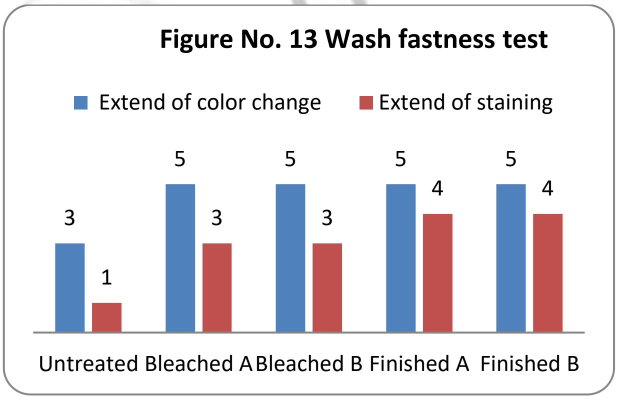


3.2.10 Spray Test

Comparing the water repellence by test spray test of the original sample and treated sample. Results showed that the water repellence of the original sample (50- complete wetting on upper side) treated sample gave very poor water repellent properties that is (0 - Complete wetting of whole upper & lower surfaces) as they immediately got wet as soon as the water was sprayed.

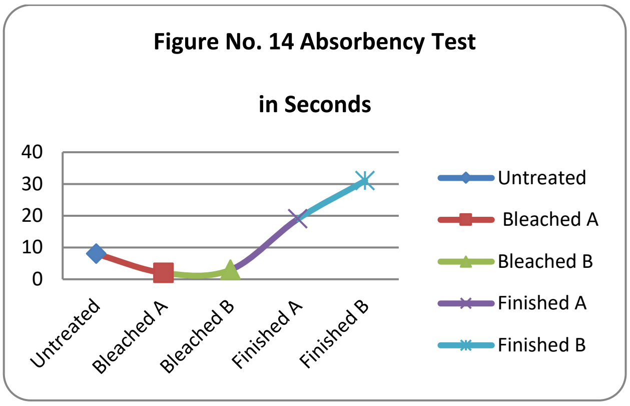
3.2.11 Rub Fastness Test

It was resulted that in dry form extend of colour change of all samplewere excellent whereas staining of dry rub fastness was very poor in the original sample followed by bleaching A, bleaching B and poor in Finished A followed by Finished B.Result showed in wet fastness was good in Bleached and finished sample; moderate in untreated sample. Staining was seen very poor in untreated sample.



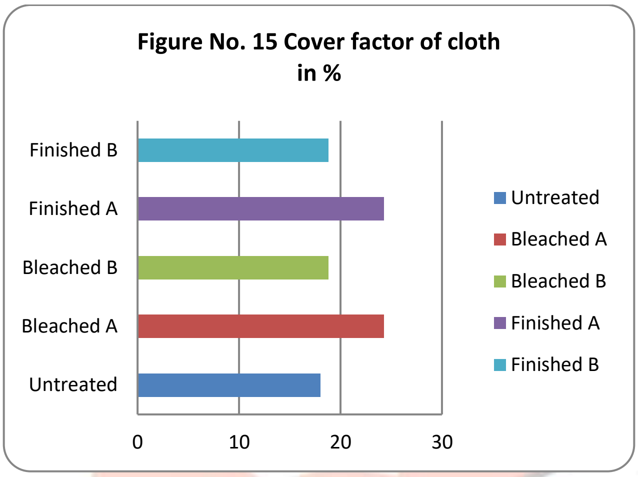
3.2.12 Wash Fastness Test

It was resulted that in wash fastness colour change sample was moderate in untreated sample. Staining was good in Finished A, Finished B whereas moderate in Bleached A and Bleached B. Extremely poor staining was seen in untreated.



3.2.13 WaterAbsorbency Test

Results showed that the Water Absorbency rate of original sample was higher than Bleached A (Hydrogen peroxide) and Bleached B (sodium hypochlorite) whereas lower than Finished B followed by finished A. In Finished sample it was increased due to due to penetration of chemicals.



3.2.14Cover Factor Of Cloth

Due to removal of starch it shrunk becomes more compact which increased the cover factor of sample. Higher the cover factors, higher the UV protection and vice- versa. The untreated sample and finished samples showed less cover factor whereas in bleached sample it was increase the fabric cover factor. The least cover factor was seen in untreated fabric.

3.2.15 Ultra Protective Factor

Sample	UPF Rating	Transmission of UVA in %	Transmission of UVB in %	% UV Radiation Blocked
Untreated	2000	0.05	0.05	99.95
Bleached A	1999.40	0.75	0.75	99.25
Bleached B	1998.42	0.75	0.75	99.25
Finished- A	2000	0.05	0.05	99.95
Finished- B	2000	0.05	0.05	99.95

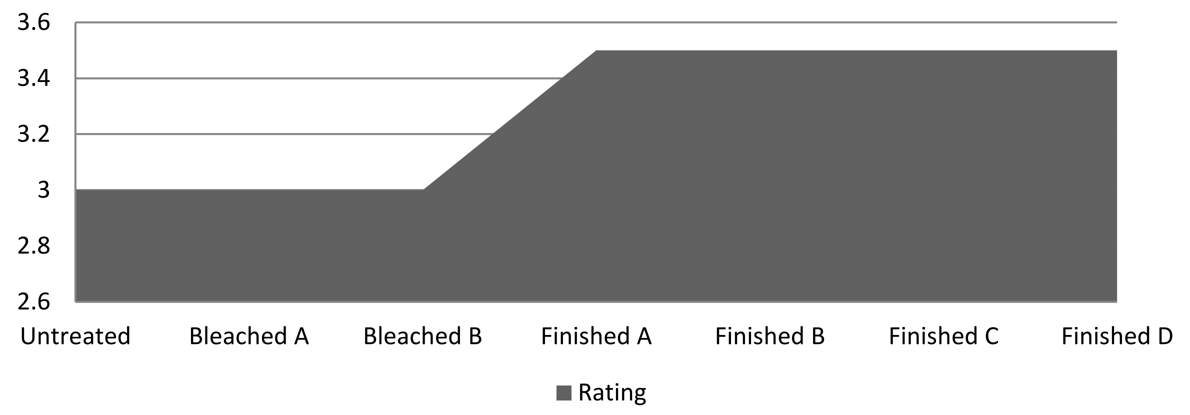
Table No. 1 Ultra protective factor

The result obtained in the evaluation of UPF was seen that the UPF rating of untreated, both bleached and UV finished sample has marginal change but it has an excellent UPF rating. Transmission of UVA and UVB increased after bleaching and after UV finished sample it was decreased by 0.05. In all samples % UV radiation blocked by 99% to 100%.

3.2.16 Colour Fastness To Ozone Test

As in the figure all treated (finished) samples indicated results of fairly good followed by untreated and bleached sample were moderately fair. Finished C and Finished D was treated only with anti-ozone softeners whereas Finished A and Finished B was treated with UV finish as well as anti-ozone softeners. Thereby Finished A and Finished B gave double protection i.e. from Ultraviolet radiation as well as Ozone fatness property.

Figure no. 16 Color fastness to ozone



IV. CONCLUSION

In the burning test, microscopic structure, fabric analysis as well as their chemical reactivity it was confirmed that it was 100 % cellulosic indigo denim fabric. Properties of yarn were good and no significant difference was observed in post applications of the finish. The thickness of untreated fabric to treated fabric was changed marginally. Air permeability of UV finished sample was decreased which helps to improve UPF of the sample. In Fabric count of samples changes was found in bleached sample and UV finished samples. Fabric weight of bleached and UV finished sample was decreased. Denim treated with Sodium Hypochlorite gave a higher degree of whiteness as compare to denim which was treated with hydrogen peroxide. Breaking strength bleached sample was decreased whereas after UV protection finish it was increased. The Ultra Protection Factor value of untreated and treated denim was excellent whereas improved in blocking of UV radiation in Treated sample. Treated has very poor water repellence as they got immediately wet as soon as the water been sprayed on fabric. Rub fastness of the dry sample extends of colour change of all denim samples were excellent whereas staining of dry rub fastness was extremely poor in untreated sample. Wet rub fastness wet fastness was good in Bleached and finished sample whereas moderate in untreated sample. Staining of wet rub fastness was seen extremely poor in untreated sample. Wash fastnesscolour change sample was excellent in all bleached as well as treated sample and moderate in untreated sample. Extremely poor wash fastness staining was seen in untreated. The Water Absorbency rate of the original sample was higher than bleached sample and lower than Finished. The untreated sample and finished samples showed less cover factor whereas in bleached sample it was increased. Colour fastness to ozone of all treated denim was fairly good followed by untreated and bleached sample were moderately fair.

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