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Impact of the Utilization of Nano Silver particles in Textile Materials

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Abstract

The natural fibre products are found to be much more environment friendly. They would also offer economical benefits to a number of developing countries, where vegetable fibres are grown and cultivated in large quantity. The use of nanotechnology in textiles aims to improve the material's functionalities or give it new characteristics ("Smart Clothes"). Nano particles can be released by mechanical load, abrasion and other external influences. This study mainly focuses on the application of Nano Silver to Tencel and its blended textile yarns, converting them to materials, dyeing with selected Natural Dyes and subjecting to Bio enzyme wash. The impact of this study would create a demand for comfortable, clean and hygienic textile goods which would cal for an urgent need for production of antimicrobial textile goods. With the advent of new technologies such as nano silver and new fibres, the growing needs of consumers in terms of health and hygiene can be fulfilled without compromising issues related to safety, human health and the environment.

Keywords*: Textile; Silver particles; Fiber.*

1. INTRODUCTION

The history of textiles is as old as human civilization. Industrially used for protection against nature, textiles were required increasingly to satisfy man's aesthetic needs for colour and ornamentation in apparels and surroundings. The word 'textile', is derived from the latin term textiles for woven fabrics. Textiles fabrics originally took their names from the place where they first acquired excellence and retained these names long after the local manufacture had been transferred elsewhere.

In the 18th century, production of textiles was the most important industry in Britain. Throughout the 20th century, the trend in textiles has been toward lighterweight materials. Better transportation and improved indoor heating have made warmth a less important aspect of clothing for most people than it was in earlier centuries. Since 1900, the weight of average clothing fabric has fallen by more than 1/3. Over the past few decades, a new textile world has emerged. New fibers, new fabrics and new finishes make new demands for understandings evaluation.The most familiar cellulosic fiber is cotton. Cotton is basically a self pollinated crop. cotton is the most vital crop of commerce popularly known as "white gold". In India, cotton is grown in extremely diverse soil and agro-climatic conditions such as arid subtropical to humid tropical wet climates and from deep heavy vertisols to sand loamy alluviums and red laterite soil. Cotton is grown in India in three distinct zones

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like north, central and south. Bains et al. 2006, proposes that the varieties of cotton are Gossypium hirsutum, Gossypium arboreum, Gossypium herbaceum and Gossypium barbadenese.

Cotton fiber, once it has been processed to remove seeds and traces of honey, protein, etc., consists of nearly pure cellulose, a natural polymer. Cotton production is very efficient, in the sense that ten percent or less of the weight is lost in subsequent processing to convert the raw cotton bolls (seed cases) into pure fiber. The cellulose is arranged in a way that gives cotton fibers a high degree of strength, durability and absorbency. Each fiber is made up of twenty to thirty layers of cellulose coiled in a neat series of natural springs when the cotton boll is opened, the fibers dry into flat, twisted, ribbon-like shapes and become kinked together and interlocked. The interlocked form is ideal for spinning into a fine yarn.

The Cellulosic fiber also includes the new fiber called Tencel in 30 years and being made of wood pulp cellulose, it is the first new natural fiber in a lot longer than that tencel comes under the viscose fiber. Viscose fiber made involves polluting chemical processes and there are many research efforts to find eco-friendly non-polluting manufacturing processes for the manufacture of cellulosic fibers.

Lyocell has been the first outcome of these efforts and it is a natural fiber made of cellulose from specific varieties of trees and more importantly. It is made by using non-chemical treatment. Tencel has a circular cross-section of 11-13 microns dia at 1.7 dtex and a saw toothed mechanical crimp.

Tencel has an interesting feature that lies in the possibility to make a fibrillisation process after weaving or knitting. i.e. in spinning a normal yarn is produced and the softening of the surface is effected at the fabric stage through fibrillisation.

In India, denim suitings made out of tencel are already in the market. These denims are said to have softness and drape that normal denims do not have. Tang et al. 2006 aver that the high strength and modulus of lyocell translate into fabric properties characterized by high tensile and tearing strength with cotton. Properly constructed and finished fabrics show excellent wash stability and an abrasion resistance comparable to cotton fabrics.

Blending is the process in which two or more different kind of fibers are spun together defines (Mahale et al. 2006). In addition various types of monofitaments or filament yarns may be combined or twisted together to form a combination filament yarn. Cellulosic fibers are often included in blends or mixture to give increased absorbency and comfort, decreased static electricity accumulation and pilling, increased washability and greater affinity to dye stuffs and chemicals in finishing.

The stress-strain characteristics of tencel make the fiber very suitable for blending with other fibers, both cellulosic and synthetic, giving a proportional increase in strength. Inclusion of tencel in a blend can therefore contribute significantly to improving performance in terms of strength and regularity, even at quite low blend levels.

The stress-strain curve for tencel is very similar to cotton. Therefore tencel is able to contribute significantly to strength of cotton blend yarns, even at low blend levels, despite very different extensions at break. This is in marked contrast to blends of cotton with other high strength fibers. Tencel / cotton yarns show an increase in strength over the whole blend range.

Tencel can be woven in 100% tencel fabrics or blended with other fibers. Tencel is yarn dyed and absorbs colours much better than most other fibers.

Tencel satisfies the consumer as it fabulously possesses the properties of five important and basic natural fibers. It also offers good performance and appears to the awareness of environmental issues by being eco-friendly.

The use of nanotechnology in textiles aims to improve the material's functionalities and to give it new characteristics ("Smart Clothes"). At present there are dirt and water-repellent as well as antibacterial textiles on the market. Many manufacturing processes are still rather cost-intensive, but there are already "nano-textiles" on the market, although it can be assumed, that "nano" is being used to advertise otherwise conventional products. "Nano Textiles" can be produced by a variety of methods such as nanoparticles are integrated into the fibres or the textile, or are applied as a coating on the surface, or whether nanoparticles are added to the nanoscale fibres or coating. Nano silver is a powerful and natural antimicrobial agent that has been proven highly effective in fighting a whole range of microbes. Acting as a catalyst, it reportedly disables the enzyme that one-celled bacteria, viruses, and fungi need for their oxygen intake without causing corresponding harm to human enzymes or other parts of the human body chemistry. The result is the destruction of disease-causing organisms without any detrimental effects on the surrounding human tissue.

Natural dyes are defined as the colours which are extracted from a combination of vegetable, mineral and insect sources defines. Natural dyes are derived from plants, insects and mineral. Though difficult to obtain commercially, natural dyes are readily obtained from plant sources, viz; Flowers, leaves, barks, seeds, roots etc. Some very good shades can be obtained from animal kingdom. Till 1856, all dyes were extracted from variety of plants as well as from a few animal sources.

The invention of synthetic dyes nearly stopped the use of naturally occurring colouring matters because of certain advantages that artificial dyes have over natural dyes like good repeatability of shades and brilliance in colour performance.

The application of natural dyes, which has once again caught the attention of the world, offers itself as an effective eco-option to the use of artificial dyes in textiles. (Iyer et al. 1999) declares the growing interest in natural dyes is already reflected in the demand for textiles dyed with natural dyes from western countries.

Natural dyes are non-pollutant as they are non-toxic and their handling is easy. There are no health hazards and sometimes they act as health care. Natural dyes are considered eco-friendly provided metallic salts used are the safer ones. Natural dyes are biodegradable and have higher compatibility. Modern tests have verified the safety of natural dyes as food colorants and many are in the list of FDA's approved food dyes. Therefore the ancient craft of dying with natural dyes assumes relevance in the present.

History of Natural Dyes walks towards as such that in every civilization, from the remote ages to the present day, colour has played an important part in adding beauty to the world. It is difficult to tell when exactly people started making colours, but it must have been pretty early since their evolution. (Sekar 2000) show that the coloured fragments of madder dyed cloth have been found in the ruins of the Indus valley civilization of Mohen-jo-daro and Harappa in 3500 B.C. The roots of plants are credited with toxic, astringent, antidysentric and antiseptic properties. Purpurin is the main colouring principal in roots while Munjistin, an orange dye occur in the form of glucoside. They form an ingredient of several medicines. The purple robes of rules of Roman Empire were from the dyed cloth exported from Harappa. During the 4th century B.C., production of printed textiles was in vague here using dyes derived from roots, leaves and stones.

India has a very rich tradition of using natural dyes. The evidence of use of natural dyes during pre-moghul and moghul period of Indian history is much preserved in the form of paintings, manuscripts etc. The coloured exquisite silk and muslin fabrics of India had acquired fame throughout the world during the 16th and 17th centuries mentions (Rameshwar et al. 2007) and Gupta, (2001). Dyeing, printing and painting were

not the only uses of natural dyes. Such dyes were extensively used as cosmetics especially by women folk, e.g. Henna/Mehandi for decorating the palms and soles, catechu with lime (and betel leaf for tinting the lips), surma to heighten the effect of eye lashes. They are also used till today in food and confectionery, e.g. saffron, turmeric, Kashmir chilli etc. Thus for centuries man used colour derived from nature, for tinting his skin and later for the coloration of natural fabrics which he made from cloth, silk and wool.

2. METHODOLOGY

The Methodology comprises the following

2.1 Selection of Fabrics and Applications on Nano Silver

The fabrics selected for the study are 100% tencel and tencel cotton blend. Before the weaving process single yarn was treated with nano silver and then the fabrics were woven and procured. So, fabrics of original materials as well treated with nano silver materials of 100% tencel and tencel cotton blend were taken for the study.

2.2 Processing of Fabrics

The 100% tencel and tencel cotton blended fabrics of original materials as well treated with nano silver materials were bleached using six per cent hydrogen peroxide to get whiter fabrics. The bleaching solution was prepared by dissolving two per cent caustic soda and six per cent hydrogen peroxide with M:L ration 1:10. The fabrics were rinsed in a solution of soaping oil (50ml / litre of water). The fabrics were then rinsed in tinopal solution (25gm/lit of water) and dried.

2.3 Selection of Natural Dyes

The natural dyes selected for the study were Amla and Beetroot which are good sources of natural dyes for dyeing original materials as well treated with nano silver materials of 100% tencel and tencel cotton blended fabrics.

2.4 Selection of Mordants

The mordants selected for the study were two metallic mordants namely copper sulphate and Ferrous sulphate. Copper sulphate is known as “Blue Vitriol”. It can be used as either a pre-mordant or as an after-mordant. Ferrous Sulphate is known as “Copperas” or “Green Vitriol”. It is light green in colour. It is a commonly used as mordant for natural days.

2.5 PILOT STUDY

2.5.1 Preperation of Dye solution

The dye solution was prepared based on the weight of the fabric to be dyed. The concentration of the dye solution was kept as three per cent maintaining the M:L ratio as 1:10 at a temperature of 100°C for 60 min.

2.5.2 Preperation of Mordant Solution

The mordant solution was prepared based on the weight of the fabric to be mordanted. The concentration of the mordant solution was kept as two per cent maintaining the M:L ratio as 1:10 at a temperature of 100°C for 60 min.

2,5.3 Selection of Mordanting Techniques

The mordanting techniques selected for the study were Pre-mordanting, Post-mordanting, Simultaneous mordanting and Pad mordanting.

2.5.4 Selection and Application of Dying procedure

Amla dye of concentration three per cent was taken based on the weight of the fabric and was mixed well in the M:L ratio of 1:10 and the solution

was boiled for 1 hour at a temperature of 100ºC.Similarly, the chemical mordant Copper Sulphate of concentration two per cent was taken based on the weight of the fabric and was mixed well in the M:L ratio of 1:10 and the solution was boiled for 1 hour at a temperature of 100ºC. The pre-mordanting technique was followed by first impregnating the bleached 100% Tencel original fabric as well treated with nano silver materials in the mordant solution for 1 hour at a temperature of 100ºC and then boiled in Amla dye solution for 1 hour at a temperature of 100ºC.Then the fabric was squeezed and soaked in soap solution. It was then rinsed thoroughly in cold soft water and dried in shade. The same parameters were carried out to dye the other fabric using the natural dye, the chemical mordant and the mordanting techniques which was carried out to obtain the desired dyed samples.

2.5.5 Selection of Dyed Treated Samples for the Study

The samples for the study were selected based on the best natural dye, the best mordant and the best mordating techniques. Out of the desired dyed samples undertaken for the pilot study two samples were selected for the major study. They are 100 % Tencel of original materials as well treated with nano silver materials dyed with three per cent Amla natural dye, two per cent copper sulphate mordant using pre mordanting. And the second sample was Tencel Cotton Blend of original materials as well treated with nano silver materials dyed with three per cent Amla natural dye, two per cent copper sulphate mordant using simultaneous mordanting.

2.6 Dye Fixing using Fixative

The fixing agent Potassium dichromate of concentration five per cent was taken based on the weight of the fabric i.e.500 gm and was mixed well in the M:L ratio of 1:10. 100% Tencel and Tencel Cotton blended dyed fabrics of original materials as well treated with nano silver materials were soaked in the fixing solution for two hours at atmospheric temperature. Then the fabrics were squeezed and soaked in soap solution and then they were thoroughly rinsed in cold soft water and dried.

2.7 Bio - Enzyme Wash

Bio-enzyme washing is the abrasion of yarn in the fabric by the abrasive action of enzymes on the garment surface, which removes some of the dye. Enzymes facilitate the removal of natural or applied impurities and help modify the physical properties of textiles. A small dose of enzyme can replace several kilograms of stones used in washing. It reduces the damage caused on the fabric and produces less wear on machines and less dust in the working environment.

Enzymes have opened up new possibilities in both finishing and washing by increasing the variety of finishes and washes available. It is now possible to fade fabrics to a greater degree without running the risk of damaging the fabrics. This can be effectively done by using enzymes like lactase or peroxidase replacing bleaching chemicals like hydrogen peroxide or hypochlorite.

The dyed 100% Tencel and Tencel Cotton blended fabrics of original materials as well treated with nano silver materials was treated with fixing agent namely potassium dichromate. Water and acetic acid of the required percentage is added and made to run for 5mins, to reduce the pH of water. This is done to make the chemicals soluble in water and the fabrics will be reacted with the chemicals easily. The pH value for bio enzyme wash is five. Then add the fabrics and MCM 2LA enzyme and run for 60min at 55^0C. After this drain out the liquid and again add water, acetic acid and silicone softener and run for 10mins. Load the fabrics in hydro and dry it in tumble dryer. Remove the pilling over the fabrics. Thus the fabrics are bio-enzyme washed.

2.8 Fabric Tests

2.8.1 Burning Tests

The fibers in a fabric that is unknown can be identified by a simple burn test if the fabric is a

Table 1. Burning Tests

S.No	Properties	100% Tencel	Tencel / Cotton Blend
1	In Flame	Burns readily	Burns readily
2	Odour	Burning paper odour	Burning paper odour
3	Flame Colour	As usual	As usual
4	Ash Colour	Black	Black
5	Constituent Fiber Group	Cellulosic fiber	Cellulosic fiber

natural fiber, man-made fiber, or a blend of natural and man-made fibers. The burn test is the basic test used to identify the constituent fibers in a fabric.Fabric samples of dimension 2 x 2 inch were ignited and the reactions of the fabric to the flame taking into account the various aspects such as ash colour, odour, steadiness of the flame, etc are determined. Based on these characteristics the fiber group of the fabric is found. Samples of 100% tencel and tencel cotton blend fabrics were taken and tested to find out the burning properties. The results are discussed in Table I under results and discussions.

2.8.2 Physical Tests

The Physical tests such as for Appearance, Colour, Luster, Flexibility, Elasticity, Absorbency and Feel of 100% tencel and tencel cotton fabrics are visualized and the results are discussed under results and discussion.

2.8.3 Colour Fastness Tests

The colour fastness tests to light, washing and rubbing was carried out using ASTM standards.

2.8.4 Mechanical Tests

Mechanical tests such as Fabric GSM, Thickness, Tensile Strength, Abrasion Resistance, Drape Coefficient, Shrinkage, Stiffness and Crease Recovery. Consecutive random samples of 100% tencel and tencel cotton blended fabrics for grey, bleached, dyed, bio enzyme washed fabrics of original materials as well treated with nano silver materials were taken, tested to find out the results using ANOVA. The results are discussed under results and discussion.

2.9 Construction of Appearal

Apparel namely shirt was constructed for the age group of 18-20 years to find out the performance between original and nano silver treated 100% Tencel bio-enyme wash apparel with original and nano silver treated Tencel Cotton blended bio-enyme wash apparel. The shirt were worn by a college going girl for ten days from evening 5.p.m to morning 6.a.m. for about 13 hours per day and was subjected to consecutive ten washes. A subjective evaluation was carried out to find out the performance of original and nano silver treated 100% Tencel and Tencel Cotton blended fabrics and the results are discussed under results and discussion.

3. RESULTS & DISCUSSION

Evaluation is the systematic determination of merit, worth and significance of something or someone. Evaluation of samples was tested both subjectively and objectively.

3.1 Burning Tests

Burning tests were done by the following objective evaluation method to find out the constituent fibres of the fabric used for the

study.100% Tencel and Tencel Cotton blended samples were taken and tested to find out the constituent fibres and the results are shown in Table I.

Hence the results of burning test show that the constituent fiber of the fabrics used for the study is cellulosic fiber group.

3.2 Physical Tests

The results show that the Physical properties for Appearance, Colour, Luster, Flexibility, Elasticity, Absorbency and Feel of 100% Tencel fabric is good compared to Tencel Cotton blended fabric.

3.3 Colour Fastness Test

Colour fastness tests were done following objective evaluation method to find out the colour fastness properties to light, washing and rubbing was carried out using ASTM standards. The average result for colour fastness to light show that Tencel Cotton blended fabric of original materials as well treated with nano silver materials is good when compared to 100% Tencel fabric of original materials as well treated with nano silver materials. The average results for Colour fastness to washing show that 100% Tencel fabric of original materials as well treated with nano silver materials is good when compared to Tencel Cotton blended fabric of original materials as well treated with nano silver materials. The average results for Colour fastness to dry and wet rubbing show that 100% Tencel of original materials as well treated with nano silver materials is good when compared to original materials as well treated with nano silver materials of Tencel Cotton blended fabric.

3.4 Mechanical Tests

Mechanical tests such as Fabric GSM, Thickness, Tensile Strength, Abrasion Resistance, Drape Coefficient, Shrinkage, Stiffness and Crease Recovery. Consecutive random samples of 100% tencel and tencel cotton blended fabrics for grey, bleached, dyed, bio enzyme washed fabrics of original materials as well treated with nano silver materials were taken, tested and the results show thus:

The results for **Fabric Weight** show that when compared between original Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics is high compared to original 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics. When compared between nano silver treated Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics is high compared to nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics. Hence, it could be concluded that nano silver treated and original 100% Tencel materials has proved to be of light weight.

The results show that the **Fabric Thickness** of original 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics is high compared to original Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics. When compared between nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics is high compared to nano silver treated Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics. Hence, it could be concluded that nano silver treated and original 100% Tencel materials has proved to be fine.

The results of **Tensile Strength and Elongation** for **Ravelled method** when compared between original materials of 100% Tencel and Tencel cotton blend materials as well between treated nano silver materials of 100% Tencel and Tencel cotton blend materials reveal that for 100% Tencel show that the Tensile strength of Grey fabric of original and nano silver treated in warp way is good when compared to dyed, bleached and Bio-enzyme washed fabrics. The Tensile strength of Grey fabric of original and nano silver treated in weft way is good when compared to dyed bleached bio-enzyme washed fabrics. The Elongation of dyed fabric of original and nano silver treated in warp

way is good when compared to grey, bleached and bio-enzyme washed fabrics. The Elongation of dyed fabric of original and nano silver treated in warp way is good when compared to grey, bleached and bio-enzyme washed fabrics. The results for Tencel cotton blend show that the Tensile strength of dyed fabric of original and nano silver treated in both warp and weft way is good when compared to grey, bleached and bio-enzyme washed fabrics. The Elongation of dyed fabric of original and nano silver treated in warp way is good when compared to grey, bleached and bio-enzyme washed fabrics. The Elongation of grey fabric of original and nano silver treated in weft way is good when compared to bleached, dyed and bio-enzyme washed fabric.

The results of **Tensile Strength and Elongation** for **UnRavelled method** when compared between original materials of 100% Tencel and Tencel cotton blend materials as well between treated nano silver materials of 100% Tencel and Tencel cotton blend materials reveal that for 100% Tencel show that the Tensile strength of Grey fabric of original and nano silver treated in both warp and weft way is good when compared to bleached, dyed and bio-enzyme washed fabrics. The elongation of dyed fabric of original and nano silver treated in both warp and weft way is good when compared to grey, bleached and bio-enzyme washed fabrics. The results for Tencel cotton blend show that the Tensile strength of Grey fabric of original and nano silver treated in warp way is good when compared to dyed, bleached and bio-enzyme washed fabrics. The Tensile strength of bio-enzyme washed fabric of original and nano silver treated in weft way is good when compared to grey, bleached and dyed fabrics. The Elongation of dyed fabric of original and nano silver treated in warp way is good when compared to grey, bleached and bio-enzyme washed fabrics. The Elongation of bleached fabric of original and nano silver treated in weft way is good when compared to grey, dyed and bio-enzyme washed fabrics.

Hence it could be concluded that the results of Tensile strength of 100%Tencel of original and nano silver treated grey, bleached, dyed and bio-enzyme washed fabrics by ravelled method was found to be good when compared with original and nano silver treated Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics. The results of Elongation of original and nano silver treated Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics by ravelled method was found to be good when compared with original and nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics. The results of Tensile strength and elongation of original and nano silver treated Tencel Cotton blended grey, bleached, dyed and bio-enzyme washed fabrics by unravelled method was found to be good when compared with original and nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics.

The **Abrasion Resistance** results reveal that the abrasion resistance of 100% Tencel bio-enzyme washed original and nano silver treated fabric is good compared to original and nano silver treated 100% Tencel grey, bleached and dyed fabrics. The abrasion resistance of Tencel Cotton bio-enzyme washed original and nano silver treated fabric is good compated to original and nano silver treated Tencel Cotton grey, bleached and dyed fabrics. Hence it could be concluded that when compared between 100% Tencel and Tencel Cotton blend material, the abrasion resistance is good in bio-enzyme washed original and nano silver treated fabric of Tencel Cotton blend materials.

The **Drape co-efficient** of 100% Tencel original and nano silver treated material of grey, bleached, dyed and bio-enzyme washed fabrics is good compared to original and nano silver treated Tencel Cotton blend grey, bleached, dyed and bio-enzyme washed fabric.

The results of **Shrinkage** shows that the Shrinkage per cen tage of Tencel Cotton blended original and nano silver treated grey, bleached, dyed and bio-enzyme washed fabric is good compared to original and nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabric.

The **Stiffness** in 100% Tencel and Tencel Cotton blended fabrics is analysed both in warp and weft directions. When the comparision is done within 100% Tencel, The Stiffness of 100% Tencel original and nano silver treated grey fabric in warp and weft ways is high compared to bleached, a dyed and bio-enzyme washed fabrics. When the comparision is done within Tencel Cotton blend, The Stiffness of Tencel Cotton blended original and nano silver treated bleached fabric in warp way is high compared to grey, dyed and bio-enzyme washed fabrics. The Stiffness of Tencel Cotton blended original and nano silver treated grey fabric in weft way is high compared to bleached, dyed and bio-enzyme washed fabrics. When compared between 100% Tencel and Tencel Cotton blend, The Stiffness of Tencel Cotton blended original and nano silver treated grey, bleached, dyed and bio-enzyme washed fabrics in warp and weft ways is high compared to original and nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics in warp and weft ways. Since the Stiffness of Tencel Cotton fabric is generally high compared to 100% Tencel fabric, it is found that original and nano silver treated 100% Tencel fabric has good drapeablity when compared to Tencel Cotton blended fabric.

The **Crease recovery angle** of original and nano silver treated 100% Tencel grey, bleached, dyed and bio-enzyme washed fabrics is good when compared to original and nano silver treated grey, bleached, dyed and bio-enzyme washed Tencel Cotton fabrics.

3.5 Evaluation of the Constructed Apparel

From the evaluation carried out for the constructed apparel, it was found that the Appearance, Colour, Lusture, Feel, Drape, Absorbency, Comfort, Easy care and Smell was good for original and nano silver treated 100% Tencel bio-enyme washed apparel when compared with original and nano silver treated Tencel Cotton blended bio-enzyme washed apparel. Hence, it could be concluded that original and nano silver treated 100% Tencel bio-enyme washed apparel was best in its performance.

4. CONCLUSION

Tencel is a manufactured cellulosic fiber which is processed with a non- toxic, recyclable dissolving agent, most of which is recycled back into the fiber manufacturing process. Hence, Tencel is naturally bio-degradable. Tencel looks elegant with a woollen or silk-like appearance mainly because of the very fine hairs that form along the fiber surface under certain conditions. Tencel possess a lustrous nature by itself make it suitable for high quality apparels. Tencel is fashionable and stylish because of silkiness. Tencel gives out an Aristocratic and Elegant Appearance. Tencel as a Confier is naturally cooling by its hydrophilic nanofibrils and help in the optimization of moisture absorption which relates to its excellent cooling properties. Tencel guarantees a pleasant dry sleeping environment though our body releases 0.4 litres of moisture and hence acts as a confier. It also possesses a unique wearable comfort. Tencel's Sensuous feels like silk and like nothing that has been ever touched. It is soft, breathable and light in weight and hence provides better feel. Tencel has good resiliency, it does not wrinkle as badly as rayon, cotton or linen and even when some wrinkles are formed they fall out when hung. Tencel fabrics provide high quality dyeing standards. Tencel dyed fabrics have proven to be very colourfast and are highly dependable. The medicinal and Functional properties of Tencel inhibit bacterial growth by controlling the temperature. It is highly suitable for sensitive skin and it is irritation free on any type of skin. Tencel is the only manufactured cellulosic fiber that possesses the properties of cotton, wool, linen, silk and polyester. Tencel is the fashion fiber of the present trend world for it possesses its own superiorities when blended with both natural and synthesized fibers. Tencel offers good physical properties like appearance, colour, lusture, feel, drape, absorbency, comfort, easycare and smell. It is irritant free as it is antibacterial in nature and hence

serves sensitive skin. Thus Tencel fabric offers the most beneficial properties when compared with other natural, man-made and blended fabrics. Due to the growing demand for comfortable, clean, and hygienic textile goods, an urgent need for production of antimicrobial textile goods has arisen. With the advent of new technologies such as nano silver and new fibres, the growing needs of consumers in terms of health and hygiene can be fulfilled without compromising issues related to safety, human health, and the environment.

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