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Sustainable Practices in Textile Industry, Current Status & Government Initiatives

The industrial innovations and developments for the rapidly changing needs of today's customers are making it more challenging to sustain in the global market. The economic growth of the industry is an essential aspect to withstand against the fluctuating markets, at the same time there is need to pay attention towards maintaining the ecological balance which is equally important to protect the environment. Many industries are now working on sustainable innovations and practices that can help to minimize the impact of industrial processes on the environment and textile industry is no exception for it. Textile industry is integral part of human being right from basic apparel to protective material. Most of the conventional textile processes use lot of resources from both natural and synthetic sources and are considered as the most polluting industry for water, air and land pollution.

Today, many sustainable practices such as utility of biobased materials, biological assisted wet processing, plasma processing for value addition of textile materials, show remarkable reduction in the effluent load on the environment that helps to maintain the ecological balance between the process and the environment. The use of bio-based material in the functionalization of textile materials has opened up a new market in the area of healthcare textile. The use of biobased materials like curcumin, aloevera and chitin which are abundantly available in nature and are much more effective, maintain the required properties in the product when being used in the actual application. The performance of these materials is also efficient against the synthetic chemicals such as Ag, Cu and trichloro based compounds which cause skin irritation and leave their traces in the environment.

There is great scope to use these bio-based materials in association with nanoscience and nanotechnology for development of value-added textile materials for various applications. The application of bio-nanotechnology is considered as one of the sustainable process in the textile processes which helps to reduce the negative impact of textile process on the environment without compromising the quality of product. The bio-based materials and its application in the field of textiles are still limited because of lack of awareness amongst people. Government initiatives such as SAATHI (Sustainable and Accelerated Adoption of efficient Textile technologies to Help small Industries), a joint initiative by Ministries of Power and Textiles aimed to provide energy efficient power looms, motors, etc. to small and medium power loom units and Project SURE (Sustainable Resolution) launched by Minister for Textiles along with Clothing Manufacturers Association of India (CMAI) are some steps taken to address critical global issues such as climate change and contribute to the UN Sustainable Development Goals 2030, for responsible consumption and production.

More efforts from the government and textile industries are required to promote research and development facility for creating and implementing sustainable innovations and bring awareness of sustainability in textile and allied area.

"Let us come together to innovate to save the environment"

Dr. V. D. Gotmare
Chairman,
Editorial Board - JTA

Antimicrobial Activity of Cotton Fabric (Cambric) Treated with Extract obtained from *Cymbopogon* (Lemongrass) for Controlling *Staphylococcus Aureus* (Bacterium)

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Abstract:
Natural antimicrobial agents are gaining more interest and in demand from the last few decades as people have become more health and hygiene conscious. These agents are eco-friendly (biodegradable), biocompatible, nontoxic and non-irritant to the skin. Present study was done on the extraction of antibacterial finish from Cymbopogon (lemongrass), its application on cotton fabric (cambric) and to report its effect on Staphylococcus aureus. Solvent extraction process and hydrous extraction process was used for extraction.. For the extraction, lemongrass was used in two forms, dried powder form and freshly made thick paste. Different concentrations (10%, 20%,30% and 40%) of lemongrass were taken to extract the finish and it was observed that 40% concentration gave a good inhibition zone by using Agar Plate Diffusion Method [1,2]and MIC(Minimum inhibitory concentration) method was performed and by which it was determined that there was 94% reduction in growth of test bacterium(S.aureus) on four times increase in extract concentration . Fabric was pre-treated by desizing method, for application of finish on the fabric after that the extracted finish was applied by using exhaustion method. Good zone of inhibition was observed in gram positive bacteria (S.aureus). Citric acid was added as a binder in different concentrations (1-10%), in order to increase the wash fastness of the fabric.. It was observed that using 10% of citric acid as a binder in extract was effective for S.aureus. After the addition of citric acid in finish, fabric was able to withstand upto ten washes. Hence, it was observed that lemongrass possesses an effective antibacterial potential where citric acid as a binder increases the durability of finish on cotton fabric and consequently treated fabric able to withstand 10 wash cycles. From the study, it was determined that Lemongrass extract has an effective antimicrobial potential, textiles finished with lemongrass extract (finish) has future applications in pharmaceutical, biomedical and health care products.

Keywords: *Agar plate, Antibacterial finish, Extraction, Inhibition zone, Pretreatment, Susceptibility.*

INTRODUCTION

Textiles and fabrics can be modified by additional functional properties apart from providing conventional properties. To improve the properties like appearance, quality and performance, fabrics are finished with natural or synthetic agents. Researchers are improving dyeing of wool and silk fabrics using natural products[3].By using mechanical or chemical methods (including wet, dry or heat), these finishes can be added at fiber stage, yarn stage. The functional finishes correspond to the next generation of finishing industry which ultimately makes the fabric act by them. Synthetic antimicrobial agents are skin irritants and cause skin allergies and also they are non-biodegradable and very serious concerns of their bioaccumulation.There is an increase in awareness of environmental concerns, so it is important to use natural finish. Natural finishing agents are considered to be an effective and potential antimicrobial agents, which can be extracted from natural sources like plants and animals. These natural finishes have advantages over synthetic finishes which are chemically made in a laboratory that they are biodegradable, skinfriendly,non-toxic, non-irritant, cost effective and easily available[4]. Natural antimicrobial agents are eco-friendly and effective against microorganism, when applied on fabrics[5,6,7].Now-a-days, there is more use of synthetic and blended fibers as compared to natural fibers in manufacturing of blouses, undergarments, shirts, hosiery . They cause more perspiration wetness as they have poor transportation properties; hence there is a need for antibacterial finish in such garments to avoid many kinds of diseases caused by bacterial pathogens. There is the serious need to use an antimicrobial finish which is eco-friendly and extracted from natural plant sources to control the growth of microorganisms.. The genus of lemongrass is "*Cymbopogon*" which belongs to a family of grass which is "Poaceae ". *Cymbopogon citratus* is a west indian grass and *Cymbopogon flexuosus* is an east indian grass. *Cymbopogon*'s common name is lemongrass. The plant's leaves have a lemony characteristic flavor because of the presence of the main content, citral. This citral is the assembly of geranial and neral isomers, which is used as a raw material for the production of vitamin-A ,beta-carotene and ionone . Lemongrass exhibits antioxidant, antimicrobial and antifungal properties. The grass grows in clusters and gains the height of 6 feet or 1.8 meters and the width can be about 4 feet or 1.2 meters and it has short rhizomes. Natural antimicrobial agents are eco-friendly[8]. Oil is also extracted from lemongrass by microwave assisted hydrodistillation (MAHD) and conventional hydrodistillation(HD) [9]..There are two types of bacteria such as gram positive and gram negative. Present study on antimicrobial effect of lemongrass extract was conducted on gram positive bacteria *Staphylococcus aureus* and lemon grass extract gave

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promising and satisfactory results in agar diffusion method, MIC, shelf life and wash fastness tests. It was observed that antimicrobial potential and effectiveness of lemongrass extract was increased by mixing citric acid as a binding agent.

OBJECTIVE

- **To extract the anti-bacterial finish from *Cymbopogon* (lemongrass) by using aqueous and solvent extraction process.**
  Solvent extraction was done by using methanol and ethanol. Hydration extraction was done by using water.
- **To apply the extracted antibacterial finish on cotton fabric (cambric).**
  Application of antibacterial finish by exhaustion method after Pre-treatment of the fabric selected by desizing of Cambric fabric.
- **To test the effect of antibacterial finish applied on cotton fabric.**
  Agar Plate Diffusion method (AATCC 147), Minimum Inhibitory Concentration of Extract , determination of the effective concentration of citric acid , testing antibacterial activity of finish on fabric after treatment of the fabric with extract ;qualitative testing by Agar Plate Diffusion Method by calculating inhibition zone and to test the wash durability of the antibacterial finish on treated fabric samples upto 10 washes using laundrometer.

METHODOLOGY

The study was done in Microbiology Laboratory and Dyeing and Printing Laboratory of Institute of Home Economics since the study is Experimental based. The study was conducted as stated below :

EXTRACTION FROM *Cymbopogon* (LEMONGRASS)

For the process of extraction, the lemongrass was first freshly plucked, washed properly and sorted to remove the dead matter and undesirable material. Two forms of lemongrass were used, Dry lemongrass powder form and Fresh thick paste form. To make the dried powder of the lemongrass, the leaves and the stem were separated out and cut into small pieces and the stems were then pounded to make them even smaller (Plate 1.). The oven was preheated at 100-150˚C. The leaves and stems were separately dried in the oven at 150˚C for approximately 2-2½ h. After the leaves and stems were completely dried, they were grounded separately in a mixer grinder to make it into fine powder and this powder was finally stored in an airtight container. For extraction from lemongrass, it was cut into small pieces and then grounded with the help of a mixer grinder by adding little water to the jar to get a thick paste. The paste was sieved by using nylon mesh and then through Whatman no.1 filter paper to remove the residual material and leftover impurities. The extract was freshly prepared and filtered the same day on which the testing was to be done. To check the shelf life of the finish, it was poured in a conical flask, plugged properly and kept inside the refrigerator for storage. The process of extraction was done by two methods:

1. Hydrous Extraction Process
2. Solvent Extraction Process

1. **Hydrous extraction process:** Different conc. of lemongrass extract were taken (10%, 20%, 30% and 40%) by mixing distilled water and dried lemongrass. These concentration mixtures were kept in separate sterilized conical flasks and plugged separately with a cotton plug. Plugged conical flasks were sealed with Parafilm and then with foil and kept in an orbital shaker at 30˚C with 100rpm for 24h. After this, the plugs of conical flasks were removed and the mixture was sieved in another sterile conical flask by using nylon mesh and then passed through Whatman no.1 filter paper. The final extract obtained was kept in a plugged conical flask for further testing. The same procedure was followed for fresh paste of lemongrass with distilled water.

2. Solvent Extraction Process: The extraction of the finish was performed by mixing dried lemongrass powder with methanol and ethanol separately in different concentrations (10%, 20%, 30% and 40%)[11,12,13,14]. The mixture was kept in separate sterilized conical flasks and it was finally plugged by using a cotton plug. Plugged conical flask was sealed with Para film and then with foil and finally kept in an orbital shaker at 30˚C with 100 rpm for 24h. After this, the plug was removed and the mixture was sieved in another empty and sterile conical flask by using nylon mesh and then through Whatman no.1 filter paper. The final extract obtained was kept in a plugged conical flask for further testing.Then the results of different conc. were analyzed and one was finalized[15].

a. Washed lemongrass stems

b. Cut and pounded lemongrass

c. Washed lemongrass leaves

d. Cut lemongrass leaves

e. Lemongrass stems powder

f. Lemongrass leaves powder

PLATE 1

PRE-TREATMENT OF THE SELECTED FABRIC

For the pretreatment process, cotton fabric (cambric) was used for the application of finish. For this, desizing was done so as to remove starch present on the surface of the finished fabric and any kind of impurities left in the fabric.

Desizing of Fabric: The fabric was first weighed and material liquor ratio (MLR) was taken as 1:40. For MLR, water was taken and boiled at 65˚C. Then the selected fabric was steeped in the boiled water for about 15-20 min. After this, it was kept for 24 h at room temp. After 24 hours , the fabric was rinsed and washed thoroughly with distilled water.. This process is known as the rot steeping method. Bacteria which grow during this process, breakdown and hydrolyze the starch and impurities present on the fabric, hence, the fabric is ready for further finishing. For the testing of the presence of residual starch on the fabric, iodine test was done. The control fabric sample and the desized fabric sample, both the samples were boiled in 100 ml of water in two different beakers. Then the samples were removed from the beakers and a few drops of iodine were put in each beaker. The results were recorded. No color change (blue-black color) showed that starch was absent in the sample.

APPLICATION OF ANTIBACTERIAL FINISH ON THE FABRIC

The finish extracted was applied by using two methods; Exhaustion Method and Direct Method. The pre-treated fabric was cut into small pieces of size 1" x 1" and the fabric samples were then dipped in the finalized concentration of the extracted finish(MLR=1:20). The fabric samples were dipped for at least 10-12 hours and kept in the refrigerator. This application method is known as the exhaustion method. The same procedure was repeated with the finish prepared using the finalized (extract+citric acid) concentrations each and also with only finalized citric acid concentration, it was considered as a control sample. After this, the treated fabric samples were put in a zip lock bag and a little amount of finish was poured inside the bag and then this bag with fabric sample, was passed through the padding mangle at 0 psi with 2 dips and 2 nips for maximum wet pickup[4,8,9,15]. After this treatment, fabric samples were then kept in a sterilized Petri dish to avoid bacterial and fungal contamination. Then fabric samples were kept in an oven at 80˚C for 7 min to let the samples dry completely. After drying, the samples were kept out of the oven to cool down, the temp of the oven was raised till 150˚C and then the fabric samples were cured at 150˚C for 3 min. This method was known as the direct method or pad-dry-cure method.

DETERMINING THE BEST PROCESS OF EXTRACTION WITH THE HELP OF AGAR PLATE DIFFUSION METHOD

Agar Plate diffusion Method

Gram positive bacteria, *Staphylococcus aureus* was used as a test organism.

Test organism *S. aureus* was freshly revived by using nutrient agar plates and nutrient broth. A well was punched in the centre of nutrient agar plate (freshly prepared) by using sterilized borer(autoclaved), the plates were then streaked with freshly revived test organism(*S.aureus*). 100 µl lemon grass extract was poured in the well (100 µl), the plates were then kept in the incubator at 37˚ for 12 hours. Plates were lifted carefully to keep in the refrigerator, in order to avoid spillage from the well. Inoculated plates were then examined for the clear zone of the zone of inhibition[10]. The average width of the zone of inhibition on either side of the well was calculated by: W=T-D/2, W= width of the inhibition (mm)T= total diameter of the well and clear zone (mm), D= diameter of the well created by borer (mm) ; 3mm.The agar plates were then streaked with test organism (S.aureus) which have antibacterial agent (*Cymbopogon* extract) in the well created by using a borer, showed a clear zone with no growth of bacteria (zone of inhibition)[4,6,8,9].

Extract showed antibacterial activity, it was ensured with a clear zone of inhibition around the well. This zone was a result of diffusion of the antibacterial agent (Lemon grass extract) around the well, in the nutrient agar. The size of inhibition zone or clear zone if, is equal to 2mm or more than 2mm, which is an indication of a good antibacterial effect.

Testing of shelf life of finish:

Till three weeks, the shelf life of the finish was tested . For this, the finish obtained from lemongrass was prepared in conical flask, flask was then plugged, sealed with parafilm and kept in the refrigerator. The testing of finish was done by Agar Diffusion Method, for three consecutive weeks, to check the shelf life of the finish.

DETERMINING MINIMUM INHIBITORY CONCENTRATION (MIC) OF EXTRACT

Two different concentrations of extracts were taken in nutrient broth ; 1X and 2X. 1X nutrient broth with 1ml of extract and 9ml of nutrient broth, 2X nutrient broth with 5ml of extract and 5 ml of nutrient broth. After that 100 µl of test organism (*S.aureus*) was inoculated in both the tubes, then the tubes were kept in the incubator at 37˚ for 12 hours. Optical density or turbidity of the solution was measured at wavelength 620 . Digital spectrophotometer was used and readings were recorded for both concentrations.

DETERMINING THE EFFECTIVE CONCENTRATION OF CITRIC ACID (Binding Agent)

The citric acid was used as a binding agent in this study, it can create cross linking bonds with the fabric and the applied finish, and helps to hold the finish on the fabric. Thus, it was used in the study to increase the wash fastness and durability of the finish. To determine the effective concentration of citric acid, a finalized extract concentration was taken and it was mixed with different concentrations of citric acid solution. The different concentrations of citric acid taken were 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9% and 10%. This mixture was also tested by the Agar Diffusion Method (AATCC 147) method to check which concentration is working best with the finish. This finish was then used for further application on fabric.

Testing of finished fabric for antibacterial activity

Qualitative Testing *[Agar Plate Diffusion Method (AATCC147)]* Agar Plate Diffusion Method (AATCC147) was chosen for qualitative testing. This method is based on the principle of obtaining a clear zone or zone of inhibition. Antimicrobial potential and efficacy was determined by a clear zone of inhibition, it shows that the herbal extract has antibacterial activity. This clear zone (inhibition zone) was formed by the diffusion of the antibacterial agent into the agar plate. For this, freshly prepared nutrient agar plates were taken and inoculated with fresh bacterial culture i.e. test organism (*S.aureus*) by streaking method, using sterilized cotton swab, over the entire nutrient agar surface. The surface of the nutrient agar plate was inoculated and swabbed by rotating the plate 60˚ after each streak. After inoculation, the inoculated plates were kept open for 5 min to let them dry. After this, treated fabric samples, which includes, the first fabric sample of size (1" x 1") which was finished with finalized concentration of 40% methanolic lemongrass (*Cymbopogon*) extracted finish, second fabric sample of same size, finished with finalized (40% lemongrass extract + 10%citric acid) concentrations. A third fabric sample was treated with finalized conc. of citric acid (10%) only and the fourth fabric sample was, untreated fabric sample (control). All the four fabric samples were kept in separate nutrient agar plates, in intimate contact with the nutrient agar, in the centre of the plates, which have been streaked with the bacterial culture i.e. test organism (*S.aureus*), after that, the plates were kept in an incubator at 37˚ for 12 hours, and then the test fabric samples were observed for the presence of clear zone or zone of inhibition, around them. Milimeter scale was used to measure the zone. Around the test samples, it was noticed that there was interrupted growth of bacteria that reflected the antibacterial activity and potential of applied finish on the fabric.

Wash durability(wash fastness) testing of the antibacterial finish of treated fabric samples

To test the effectiveness of the finish after washing, a wash durability test (wash fastness test) was performed on the treated fabric samples. The samples were subjected to different wash cycles (1 to 10) to observe the antibacterial activity after multiple washing cycles . The laundrometer was used to wash the samples. Before starting the machine, the water level was checked. The water was filled in the machine (laundrometer) till the mark, which was presented inside the machine chamber. The 40˚C temperature was set, till the temp reached at 40˚C, the machine was kept on. 0.5% of Soap solution was prepared, 5g of soap or detergent was dissolved in 1 litre of water and was heated till it became lukewarm.The treated fabric samples were put in the tiny jars and completely dipped in the soap solution and subjected to different wash cycles. Each wash cycle was set for 10 minutes time duration. The procedure was repeated till 10 washes. All the samples were further subjected to next testing by agar diffusion method.

RESULTS AND DISCUSSION

The present study was conducted on testing of antimicrobial activity of cotton fabric (cambric) treated with extract obtained from *Cymbopogon* (Lemongrass) for controlling *Staphylococcus aureus* (bacterium). The main objective of the study was to study the antibacterial potential and activity of lemongrass finish (extract) on cotton fabric (cambric). The finish was then evaluated on the basis of its efficacy against the test bacterium (*S.aureus)*. The observations, results, analysis and interpretation of the work done is discussed as follows:

Extraction from *Cymbopogon* (Lemongrass)

Hydrous extraction method and solvent extraction method were used for extraction . For hydrous extraction, water was used as a solvent and for the solvent extraction, two different organic solvents were used, which were ethanol and methanol. Both dried lemongrass powder and fresh lemongrass thick paste were used for preparing the extract. Lemongrass with different concentrations (10%, 20%, 30% and 40%) were added into different solvents water, ethanol and methanol.

The best process of extraction was determined by testing the extracts with different concentrations (10% to 40%) with the help of Agar Plate Diffusion Method by AATCC147. The effective concentration of the finish was also determined along with the finish finalization.(water based/ethanol based/methanol based) (Table1).

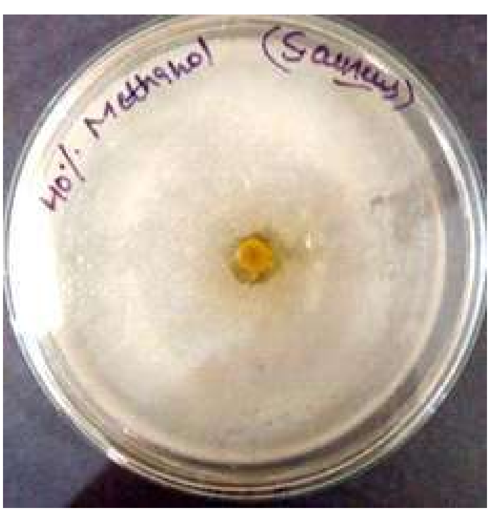
Antibacterial effect of lemongrass extract (finish) on test organism (*S.aureus*)

The best extraction process (out of three solvents water/ethanol/methanol) of the finish was determined and the effective concentration (out of 10% to 40%) of extract for *S.aureus* was recorded (Table1). The range of width of inhibition zone from 1.95-2.75 mm was observed for ethanol with lemongrass extract, The range of width of inhibition zone from 2.05-4.15 mm was observed for methanol with lemongrass extract, and the water with lemongrass did not show any inhibition against the bacteria. Hence, it was noticed that methanol with lemongrass extract (at 40% concentration) gave the highest value for width of the zone of inhibition i.e. 4.15 mm. Therefore, 40% methanolic extract concentration was considered as the best extraction process and was selected for further testing . Antibacterial activity was not observed for control samples of methanol (without extract), so, it was proved that antibacterial activity of lemongrass extract was increased and enhanced and was much higher when it was combined with methanol (organic solvent) as compared to extract alone (Plate2). It was noticed that the solvent extraction method was better than the hydrous extraction method, as lemongrass extract with methanol and extract with ethanol gave better zones of inhibition as compared to extract with water. Moreover, best results were observed with dry lemongrass powder as compared to fresh *lemongrass thick paste (Plate 2)* .

Table 1. Different Concentrations (10% to 40%) for Dry Lemongrass Powder in different solvents and zones of inhibition (mm)

S. No.	HERBAL EXTRACT CONCENTRATION (%)	ZONE OF INHIBITION (Avg. width of inhibition in mm)		
		ETHANOL	METHANOL	WATER
		S.aureus	*S.aureus*	*S.aureus*
1.	10	1.95	2.05	-
2.	20	2.75	2.8	-
3.	30	-	3.6	-
4.	40	-	4.15	-
5.	Control Sample	-	-	-

*The results were inconsistent due to error



A1. 40% Methanol

A2. Control Methanol

B1. 40% Ethanol

B2. Control Ethanol

C1. 40% Water

C2. Control Water

PLATE 2. COMPARISON BETWEEN THE HYDROUS METHOD AND SOLVENT METHOD USING 40% OF CONCENTRATION OF LEMONGRASS EXTRACT AGAINST S.AUREUS

The Minimum Inhibitory Concentration (MIC) test helped to determine percentage reduction of test organism (*S.aureus*), when the amount of lemongrass extract increased in nutrient broth. It was observed that when methanolic lemongrass extract concentration increased from 10% to 50% (4X increase, four times increase) in nutrient broth, optical density or turbidity (bacterial density) was reduced from 0.635 to 0.037 that shows 94% reduction in growth of test organism (*S.aureus)* (Table 2, Table 3)

Table 2. Minimum Inhibitory Concentration (MIC) For Extract

S. NO	Nutrient broth (N.B.) (ml)	Extract (ml)	Concentration of extract in N.B. (%)	Optical density for S.aureus
1. (1X)	9	1	10%	0.635
2. (2X)	5	5	50%	0.037

Wavelength = 620λ; Transmission % = 100; Absorbance = 0

Table 3. Interpretation of MIC

Increase in lemongrass	% Reduction of growth of bacteria
	S.aureus
4X	94

TESTING OF SHELF LIFE OF FINISH

40g of dry lemongrass powder mixed with pure methanol to prepare lemongrass finish. It was freshly prepared on the same day for testing. This finish was tested by agar plate diffusion method (AATCC147), a qualitative assessment method. The finish was tested on the first day of preparation, after that it was stored in refrigerator at 4˚C for one week. Second testing was done after one week, third testing was done after two weeks and fourth testing was done after three weeks. The results were observed and recorded after every testing, it was found that inhibition zone was present till the second week, it was interpreted that the treated fabric showed inhibition zone of 0.1mm (Table 4.) size till two weeks against test organism (*S.aureus*). Hence the shelf life of *Cymbopogon* (lemongrass) extract was determined i.e. 2 weeks. (Plate 3.)

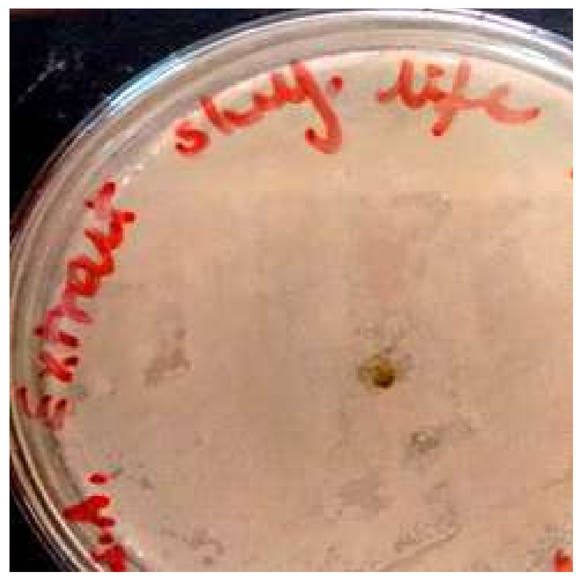
Table 4. Testing Shelf Life of the *Cymbopogon* (lemongrass)extract (Finish)

S. NO.	Age of Extract	ZONE OF INHIBITION (Avg. width of inhibition in mm)
		S.aureus
1.	Extract (fresh)	5.7
2.	1 week old	1.3
3.	2 weeks old	0.1
4.	3 weeks old	-

Lemongrass extract gave a greenish yellow color on the fabric.

Agar plate Diffusion Method was used to test the antimicrobial efficacy of treated fabric sample. It was noticed that finish was not diffused on the surrounding agar surface and results were analysed and recorded on the basis of clarity of the zone of inhibition (Table 5) it was observed that Treated fabric with 40% methanolic dry lemongrass powder herbal extract, showed a clear zone of inhibition before wash and after first and second wash, zone of inhibition was also observed after third to seventh wash but clarity was reduced, after eighth, ninth and tenth washes growth of bacteria observed beneath the fabric. Treated fabric sample with 40% methanolic dry lemongrass extract + 10% citric acid showed clear zone of inhibition before wash and after first to fourth wash, zone of inhibition was also noticed after fifth to tenth wash but clarity was reduced (Table 5,Table 6). Different concentrations of citric acid (1% to 10%) were taken and each concentration was tested by agar diffusion method. It was determined that 10% citric acid concentration along with

A1. 1st week methanolic extract



B1. 2nd week methanolic extract

PLATE 3. TESTING OF SHELF LIFE OF FINISH

lemongrass extract was effective as the maximum zone of inhibition i.e.6.3mm. so 10% citric acid was chose and all other concentrations were rejected (Table 5, Plate 5).Treated fabric sample with 10% citric acid (the control sample) showed a clear zone of inhibition before washing, after first and second wash and zone of inhibition was observed after third to sixth wash but clarity was reduced (Table 6). It was also noticed that clarity of inhibition zone was more when extract was mixed with 10% citric acid as compared to extract alone and growth was observed beneath the fabric (control sample). Hence, it was proved that washing durability increased upto tenth wash by adding citric acid in the extract. Thus, it was interpreted that if citric acid (10%) is used as binder it increases durability of lemongrass herbal finish on the cotton fabric. Order of efficacy observed was Extract +10% citric acid > Extract > 10% citric acid (Plate 4).

PRE-TREATMENT OF THE FABRIC SELECTED

Pre-treatment of the fabric was performed by desizing the cotton fabric (cambric). Desizing was done to remove any kind of impurity or starch present on the fabric surface and to make it ready for finishing. To check the presence of starch on the desized fabric, an iodine test was performed. After desiring treatment iodine was added to boiled water and no blue black was noticed. Hence, it was interpreted that starch was hydrolysed and removed from the fabric surface.

APPLICATION AND ASSESSMENT OF ANTIBACTERIAL FINISH ON THE FABRIC

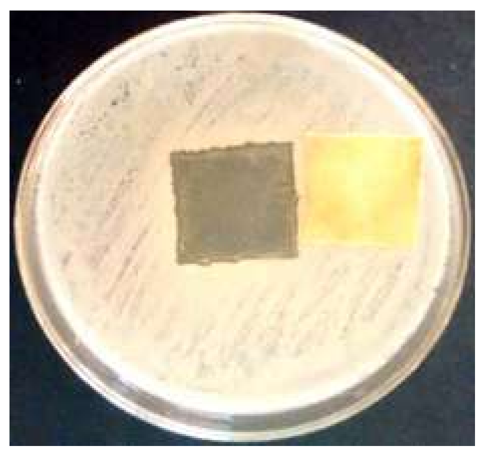
The cotton fabric (cambric) sample of size 1” x 1” was finished with 40% methanolic dry lemongrass extract. Exhaustion method and pad-dry-cure method were used to apply finish on the fabric. Fabric sample finished with

Table 5. Determining the Effect of Lemongrass Extract on Cotton Fabric, stages of washing, response of *S.aureus* to extract (with and without citric acid(10%).

S. NO.	Stages of washing (zone of inhibition)	Dry lemongrass extract with methanol (zone of inhibition)	Extract +10% citric acid (zone of inhibition)	10% citric acid (control) (zone of inhibition)
		S.aureus	***S.aureus***	***S.aureus***
1.	Before washing	++	++	++
2.	1st wash	++	++	++
3.	2nd wash	++	++	++
4.	3rd wash	+	++	+
5.	4th wash	+	++	+
6.	5th wash	+	+	+
7.	6th wash	+	+	+
8.	7th wash	+	+	-
9.	8th wash	-	+	-
10.	9th wash	-	+	-
11.	10th wash	-	+	-
12.	Control sample (untreated)	-	-	-

++ Clear zone of inhibition present; + zone of inhibition present; - growth of bacteria present

40% Dry lemongrass extract


E+10% Citric Acid

10% Citric Acid

Fabric without finish (control)

PLATE 4. TESTING OF TREATED FABRIC WITH EXTRACT ON THE BASIS OF ZONE OF INHIBITION (CLARITY) USING S.AUREUS

Table 6. Determining the Effect of Different Conc. of Citric Acid on the basis of Zone of Inhibition

S.NO.	Plates [Extract (E)+ % Citric Acid]	ZONE OF INHIBITION (Avg. width of inhibition in mm)
		S.aureus
1.	E+1%	4.3*
2.	E+2%	1.15
3.	E+3%	-
4.	E+4%	-
5.	E+5%	1.3
6.	E+6%	2.5
7.	E+7%	2.65
8.	E+8%	-
9.	E+9%	2*
10.	E+10%	6.3
11.	E+11%	-
12.	E+12%	-
13.	Control 8%	7.5
14.	Control 9%	12.65*
15.	Control 10%	10

*The results were inconsistent due to error

E+1% Citric Acid

E+2% Citric Acid

E+3% Citric Acid

E+4% Citric Acid

E+5% Citric Acid

E+6% Citric Acid

E+7% Citric Acid

E+8% Citric Acid

E+9% Citric Acid

E+10% Citric Acid

E+11% Citric Acid

E+12% Citric Acid

PLATE 5. DETERMINING THE CONC. OF CITRIC ACID

SUMMARY AND CONCLUSION

Textiles are an essential part of every human being's daily life. Synthetic and natural finishes have been used to improve the properties of the fabrics such as appearance, quality and performance. Synthetic finishes have lost their interest in the market due to their non-degradability, toxicity, they cause skin allergies and skin irritation. Due to environmental concerns associated with synthetic dyes natural and plant based antimicrobial agents are in demand today and are gaining more attention as they are eco-friendly. The world is demanding eco-friendly textiles due to increase in awareness about environmental concerns. Natural antimicrobial finish has been developed from natural sources like Lemongrass, neem, tulsi, neem,turmeric, lemongrass, garlic, aloe vera, pomegranate, hibiscus, pipal, paan leaves, green tea, etc. which are non-toxic, non-irritant, biodegradable, cost effective and easily available unlike synthetic finishes. The present study was done on woven cotton fabric (cambric) which was treated with prepared extract from *Cymbopogon* (lemongrass). To perform this study, antimicrobial finish was extracted from lemongrass by using solvent and hydrous extraction process. The fabric was treated with extracted finish and antimicrobial efficacy of the finish was determined by agar plate diffusion method (AATCC147). Two forms of lemongrass extract were used dry lemongrass extract and fresh thick paste form, out which dry form was more effective. It was also noticed that 40% methanolic dry lemongrass extract had higher antimicrobial potential against the test organism i.e. *Staphylococcus aureus* (*S.aureus*). Minimum Inhibitory Concentration test was also performed and it was determined that there was 94% reduction in bacterial growth(*S.aureus*), when lemongrass extract concentration increased to 4X (four times). Fabric samples of 1"X1” size were selected, Pre-treatment of the fabric was done by desizing to remove starch, after that finish was applied on the fabric. Citric acid was used as a binding agent, out of 1% to 10% concentrations, 10% citric acid concentration was determined as effective concentration by agar diffusion method. It was interpreted that when citric acid was mixed with 40% methanolic dry lemongrass herbal extract, antibacterial potential of the extract was enhanced, as the best size of inhibition zone was observed against *S.aureus.* It was also noticed that clarity of the inhibition zone was higher when extract was mixed with citric acid as compared to extract alone (without citric acid). Wash durability of the finish was also checked, and it was determined that when citric acid was mixed into the finish, treated fabric showed antimicrobial potential up to 10 washes. Shelf life of the finish was also determined i.e. 2 weeks. Thus, it was proved that citric acid improves the washing durability of the fabric, increases longevity of finish and also increases the antimicrobial potential of the extract.

Hence, it was concluded from the study that when 40% methanolic dry *Cymbopogon* (lemongrass) extract when mixed with 10% citric acid and applied on woven cotton fabric (cambric), treated fabric showed enhanced and effective antimicrobial activity against the test organism *Staphylococcus aureus*

Thus, lemongrass extract gave very promising results and observations in the study. Since, lemongrass is easily available, a natural, eco-friendly and nontoxic to human skin. So, it has very wide applications in textiles. Due to effective antimicrobial potential, textiles finished with lemongrass extract have future applications in pharmaceutical, biomedical and health care products.

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Morphological Structure of Sisal for Acoustic

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ABSTRACT

Sisal is a semi perennial leaf fiber producing plant, falling under the category of minor cellulosic fibers. These fibers possess encouraging properties like natural colour and strength which could be emphasized and explored at its fullest to progress in its utilization ratio. It also has some of the inherent properties like lack of cohesiveness and stiffness, due to which its percent utilization is increasing at a slower pace. Thus, enzyme treatment was incorporated to soften these fibers with various possible ways to commercialize it in future. This fiber having limited applications, an assessment was further were carried out to know structural changes by analyzing of both the untreated and treated fibers using various test methods – Bundle strength, SEM, FTIR, XRD and EDS done to identify potentiality of sisal for sound absorbing materials. While comparing both the untreated and treated fibers and also with support of previous researches, it was clear that the change in fiber orientation and diameter was observed. Also, reduction in lignin is making the fibers little softer and porous. Hence, these fibers have been taken further to spinning and fabric manufacturing phase for the development of woven sound absorbing materials.

Keywords: *Sisal Fiber, Softening Treatment, Sound absorbing materials, Structural Properties*

1. Introduction

Minor cellulosic fibers and environment both are drawing attention of researchers to produce eco-friendly products. Kapok, coir, kenaf, pineapple, bagasse, ramie, sisal, banana, etc. are various minor cellulosic fibers which are now shifting from limited utility product to functional products. Amongst these fibers' sisal having good strength, colour and a bundle of polygonal hollow sub fibers could be a good alternative for the innovative as well as an eco-friendly sound absorbing materials. The fiber being biodegradable and renewable,has some inherent characteristics like anti-static, controls humidity, natural solution for sound and thermal insulation, anti-microbial as well as anti-allergic[6]. Amongst the mentioned characteristics, it seems that strength and natural sound insulation could be explored further to create woven sound absorbing materials.

Sisal, a good substitute of synthetic fibers is in demand. The fiber being at the stage of exploration and getting recognition, need a pre-treatment which is non-hazardous to reduce its stiffness and increase its pliability. Thus, an application of enzyme treatment which is less harmful, helps in water conservation, saves energy and most important are environmentally friendly was experimented for commercial viability. The application of which has increased the softness, lustre and pliability of the fibers. Thus, further analysis was conducted to create functional products using the inherent properties.

2. Materials and Methods

2.1 Materials

Fiber Selection

Sisal fiber were purposively selected based on fiber structure and its availability fordevelopingeco-friendly sound absorbing product. The un-degummed fibers were procured from Sisal Research Station, (CRIJAF), Barrackpore, Odisha. Scouring a pre-treatment was given to remove all the impurities and to have proper penetration of enzymes in the fiber structure.

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Enzymes

Enzymes are a class of proteins that function as biocatalysts by lowering the activation energy of a reaction making it much faster. The enzymes were used for improving the feel of the fabric. Four different enzymes – Greenboost liquid (Pectinase), Biocool Z-20 powder (Hemicellulase), G-zyme axe liquid (Cellulase) and Denilite® || S (Laccase) selected for the study were procured from Rossari biotech Ltd. and Novazymes A/S. The enzymes act and reacts with each layer of the fiber amongst which lignin is the main component that keeps the fiber stiffer. These enzymes interrelate with bonds and thereby the modification in the structural properties takes place by breaking or weakening the bonds. Table 1.1 shows the different stages of treatment and process sequence.

Table 1.1: Coding of the raw and treated sisal fibers

Sr. No.	Codes	Description
1.	Sr	Sisal Raw
2.	Shcbc	Sisal - High per cent concentrated – combing - beating – combing
3.	Shcbc4	Sisal - High per cent concentrated (4hrs treatment without changing water) – combing -beating – combing

2.2 Methodology

Enzyme tretment

The treatment was carried out using a conventional lab method in which the fibers could be soaked completely into the solution and was easy to rotate the fibers with less of entanglements. Standardized recipe and procedure of previous research was applied onto the fibers with M:L ratio i.e. 1:40, temperature 55˚C and 5 pH as constant. Other variables like per cent concentration of the enzymes and treatment methods like padding mangle, beating and combing of the fibers were experimented. Finally, the application of optimized recipe was further considered for the study.

Table 2.1 - The details of optimized recipe and treatment steps

<table>
<tr><th>Sr. No.</th><th>Steps</th><th>Shcbc</th><th colspan="2">Shcbc4</th></tr>
<tr><td>1.</td><td>Beating</td><td>10mins</td><td colspan="2">10mins</td></tr>
<tr><td>2.</td><td>Combing</td><td colspan="3">Combing of the fibers in small bundles</td></tr>
<tr><td>3.</td><td>Pectinase</td><td>2%</td><td>2%</td><td rowspan="4">Stepwise addition of enzymes in single bath</td></tr>
<tr><td>4.</td><td>Laccase</td><td>10%</td><td>10%</td></tr>
<tr><td>5.</td><td>Cellulase</td><td>7%</td><td>7%</td></tr>
<tr><td>6</td><td>Hemicellulase</td><td>5%</td><td>5%</td></tr>
<tr><td>7.</td><td>Oil</td><td>25%</td><td colspan="2">25%</td></tr>
<tr><td>8.</td><td>Batching</td><td colspan="3">Overnight</td></tr>
<tr><td>9.</td><td>Combing</td><td colspan="3">Combing of the fibers in small bundles</td></tr>
</table>

The only difference between Shcbc and Shcbc4 is the enzymatic treatment steps. With the ongoing concept of water conservation, Shcbc4 samples were treated without changing the water throughout the enzymatic treatment . Once the treatment was over the fibers were washed several times under running water to remove and deactivate the enzymes. Finally, the fibers were immersed into the oil emulsion followed by batching treatment which improves the pliability by smoothing the surface texture of the fiber.

Additionally, for easy bulk treatment process with proper rotation of the fibers for the enzymes to penetrate equally. Both the process was conducted using Infracolour and Launder-O-Meter machines. By the concept of water and time management alongwith the quality of fiber, Shcbc4 using Launder-O-Meter was identified to be best commercially viable process. Thus, it was considered as a final treatment process for the study.

Evalution of fiber properties

Subjective analysis (feel and touch method) and pliability test of all the three samples raw sisal (Sr - standard sample), Shcbc and Shcbc4 (enzyme treated samples) were done. Porous structure of the fiber is one of the major factor to trap the sound. Thus, certain physical properties using ASTM methods and structural properties of the fiber were analyzed.

Tensile strength with ASTM D 3822 was carried out on Llyod Instron Tensile Test for identifying the change in the strength of fiber after the treatment and whiteness Index test was determined using CIE and ASTM D 1925 standard on Spectrophotometer instrument to identify the change in fiber colour. While to identify the morphological changes after the treatment four tests were conducted on Scanning Electronic Microscope (SEM), Fourier-transform infrared spectroscopy (FTIR), X-ray Diffraction (XRD) and Energy-dispersive X-ray spectroscopy (EDS). From the analyses one best sample was further selected for developing woven sound absorbing samples.

3. Results and Discussion

Physical properties

Straight striations without any nodes or cross markings in the structure of sisal fiber were observed under microscope. The sisle fiber having diameter of 178.7 µm and average texvalue around 278. The bundle strength found around 45.25 gm/tex. As sisal is natural fiber give variation in reading hance average of readings has been considered.

Tensile strength

The durability of any product depends on the strength, thus bundle strength of fibers using Instron machine was analyzed and the details are given in Table 3.1.

Table 3.1 - Tensile strength of sisal fiber

Sample code	Maximum Load (gf)	Extension at Max (mm)	% Strain	Tex	Stress in gm/Tex
Sr	4868.0	0.98	32.68	109.8	45.25
Shcbc	3815.81	0.93	31.12	102	39.75
Shcbc4	2684.52	0.36	11.98	107.2	24.46

The data shows, deterioration in fiber strength. On the other hand, pliability test shows reduction in stiffness. These changes could be because of the effect of enzymes on the morphological structure of the fiber. Thus, with all the above observations Shcbc4 showed best result in terms of softness and pliability.

Whiteness Index

Application of enzymes removes pectin, fats and waxes from the fiber, due to which change in natural colour of the fiber was also observed. Hence whiteness index analysis was conducted to identify the change in yellowness and whiteness, which will have an impact on aesthetic properties. The details are given in Table 3.2.

Table 3.2 - Whiteness index data of sisal fiber

Sample Code	Whiteness Index	Yellowness Index	Brightness Index
Sr	21.345	29.939	45.677
Shcbc	29.608	23.864	52.312
Shcbc4	18.917	31.059	47.312

The results indicated that the enzymatic reaction affects less to the whitening of the fibers. It was obseved from the results that whiteness and brightness increased in Shcbc and then decreased, while yellowness showed reverse results. The change in the whiteness and brightness of the fiber was due to pectinase enzyme, while yellowness was due to hemicellulase enzyme used in the treatment.

Scanning Electronic Microscope (SEM)

Each enzyme reacts with the fiber during the hydrolysis process. The schematic diagram (Figure 3.1) shows numerous elongated fiber cells which consist hemicellulose, lignin and pectin. Lignin being the major component which keeps the fiber stiffer, is difficult to break. Thus, stepwise penetration of enzymes slowly works on the fiber morphology and structural changes takes place. This morphological difference between untreated and treated fibers was compared through SEM analyses.

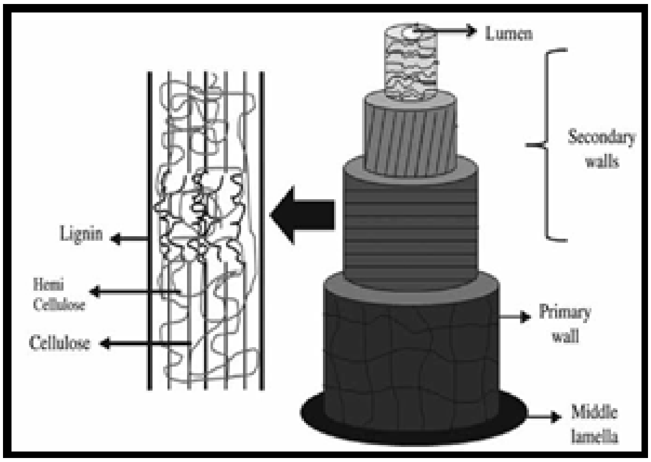


Figure 3.1: Schematic diagram of Sisal fiber cell

From the SEM (Figure 3.2), the longitudinal view of the samples shows smoother and more aligned surface was seen in Shcbc4 i.e. pithy materials are removed. Each strand is parallel to each other which could be due to the changes occurred in the inner structure, thus the fiber forms more crystalline structure. While the cross-sectional view lumen structure is clearly visible which is surround by the parallel fibrillar consists of micro-fibrillae cellulose molecular chain. The denser fiber structure having no gaps will allow less passage of sound. Thus, on comparing the three samples a hollow lumen was observed in Shcbc4.

Fourier-transform infrared spectroscopy (FTIR)

The FTIR spectra of sisal fiber samples shows similar peaks but more prominent variation in intensity in sample Shcbc4 can be observed from Figure 3.3. A broader peak range around 2900cm-1 which is associated with C-H stretching of lignin was observed in the Shcbc4 which might be weakening the lignin content due to the continuous activated laccase enzyme throughout the process. A dropping peak around 1700cm-1, associated to carbonyl (C=O) stretching of acetyl groups of hemicellulose structure of fiber, have become weaker in sample Shcbc4 compare to raw sisal (Sr) and Shcbc. C-H deformation of the lignin was also observed in the range of 1400-1500cm-1 of sample Shcbc4, which again indicates that lignin structure has broken and deteriorated. Thus, the fibers treated with Shcbc4 recipe were softer and pliable.

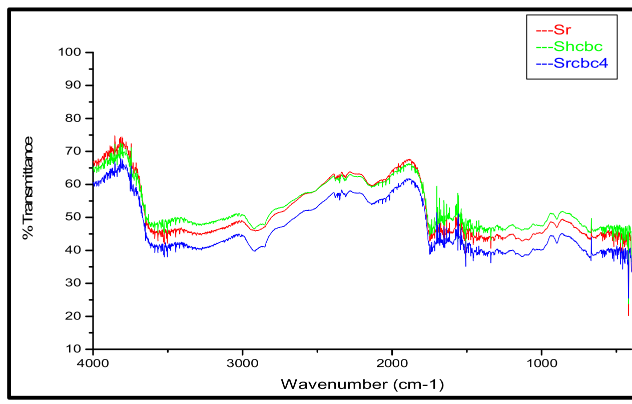
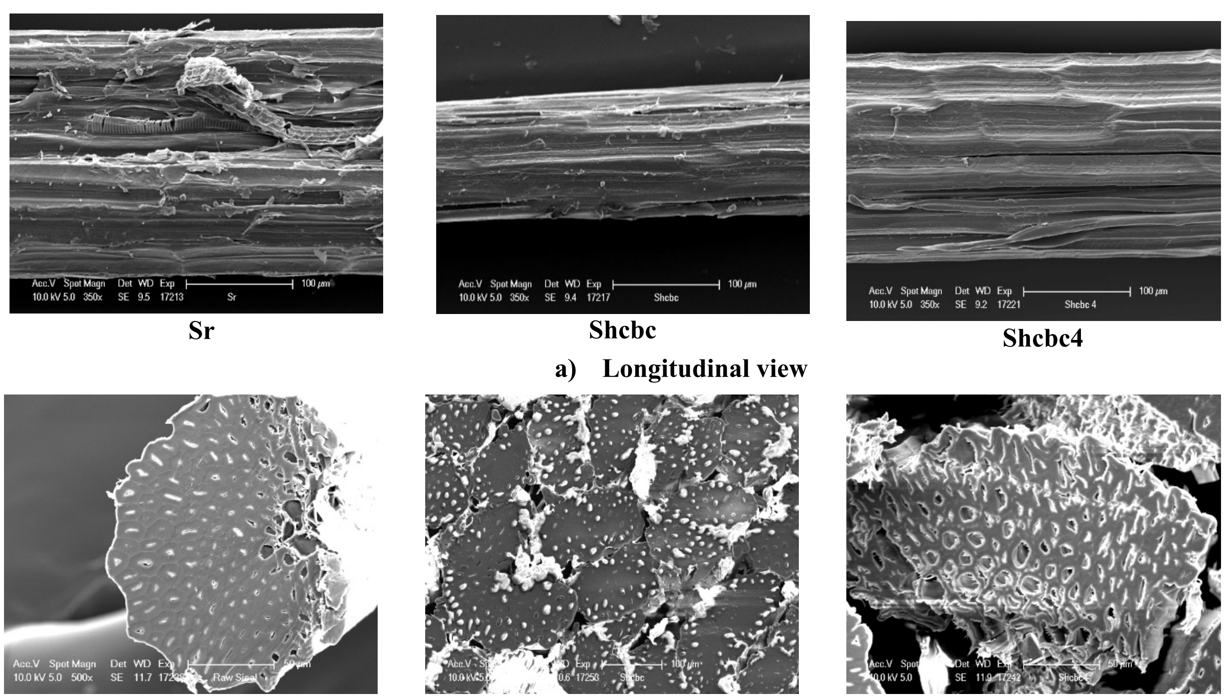


Figure 3.3: FTIR graph of untreated and treated sisal fibers



Sr **Shcbc** **Shcbc4**

a) Longitudinal view

Sr **Shcbc** **Shcbc4**

b) Cross sectional view

Figure 3.2: SEM images of raw and enzyme treated fibers

X-ray Diffraction (XRD)

XRD analysis was conducted the narrow peaks were observed which after the treatment has converted into smoother and broader curves. Reduction in crystallinity was observed with an increase in orientation angle as well as in crystallite size from Table 3.3. From the XRD analysis alonwith the cross sectional view of the fibers, it is clear that the change in size and orientation might assist in trapping and scattering of the sound passing through.

Table 3.3: XRD of bundle fibers scanned in transmission mode 10-40°

Sample Code	Crystallinity (%)	Orientation angle at 2 (°)	Crystallite Size (°A)
Sr	70.79	18.50	22.39
Shcbc	69.66	32.38	23.16
Shcbc4	67.39	31.96	25.09

Energy-dispersive X-ray spectroscopy (EDS)

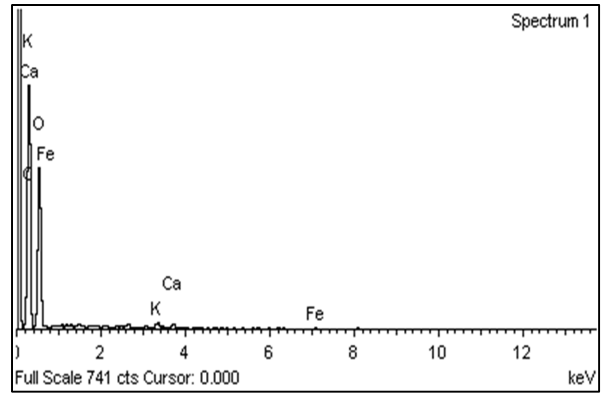
Deformation in bonds takes place after any kind of treatment or finishes. Thus, to know the change in the elements of the treated fiber EDS analysis was conducted and the details are mentioned in Table 3.4.

Table 3.4: Details of EDS elements of all the sisal fibers

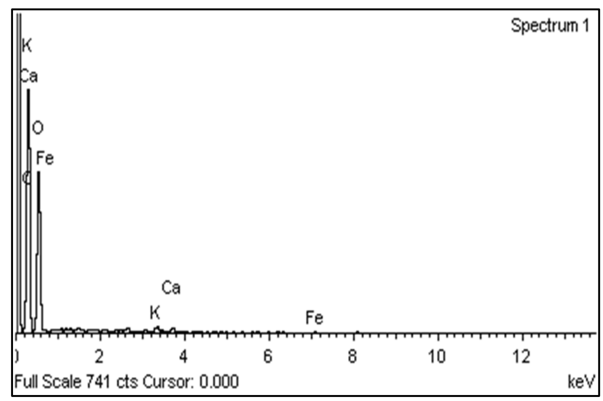
Element	Sr (Sisal raw)		Shcbc		Shcbc4	
	Weight %	Atomic %	Weight %	Atomic %	Weight %	Atomic %
C K	27.18	33.26	27.24	33.29	26.70	32.95
K K	0.14	0.05	-	-	-	-
Ca K	0.15	0.05	0.04	0.01	0.16	0.06
Fe K	0.04	0.01	-	-	-	-
O	72.50	66.62	72.62	66.63	71.67	66.41
Na K	-	-	0.06	0.04	0.39	0.25
Mg K	-	-	0.04	0.03	0.18	0.11
Cu K	-	-	-	-	0.90	0.21
Total	100.00	-	100.00	-	100.00	-

Sisal untreated fibers is composed of Carbon (C K), Potassium (K K), Calcium (Ca K), Iron (Fe K) and Oxygen (O). From the Figure 3.4, it was observed that negligible difference has been observed in carbon and oxygen, whereas reduction in calcium element (cell developing element) was seen in sample Shcbc.

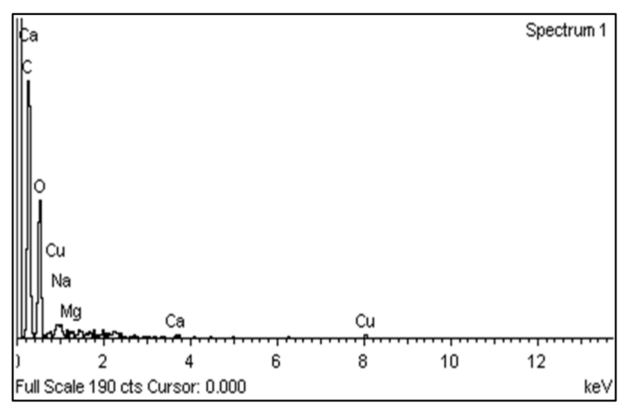
Thus, formation of cell wall or structure of cell wall must have been weakened in this particular sample compare to raw sisal (Sr) and Shcbc4.The Presence of sodium and addition of Magnesium and copper might be due to the use of soda ash for scouring and use of the containers/instrument during the treatment, but all of these elements are in permissible limit. While the removal of potassium and iron was also observed.



(a): Sr (Sisal raw fiber)



(b) : Shcbc



(c) : Shcbc4

Figure 3.4: EDS graphs of untreated and treated sisal fiber

4. Conclusions

Sisal a stiff and less cohesive fiber, are difficult to convert into woven fabric. To change both the factors, these fibers were treated with enzymes. The physical and structural analysis of sisal fibers have shown that morphologically the changes has occurred due to enzyme treatment. The swelling in the fiber and change in bonds indicates that the sound which will pass through it could be trapped. While, with the modification in the treatment process the fiber shows same effect. Additionally, the amount of water and time has reduced as well as it gives a direction to the experts in the field of technology to create such machinery like Launder-O-Meter to promote the ecological treatment process. By adapting this process eco-friendly, easily accessible with additional natural benefits innovative woven fabrics having aesthetic values could be created.

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Creating Dyeing Effect on Cotton Fabric with Disperse Dyes

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Abstract:
Availability of water for dyeing and treatment of effluent are two major problems that Indian textile processing industry facing difficult to resolve. Consumption of water in dyeing of cotton using reactive dye is very high. In the present study, fabric samples were modified using different concentrations of resin. These modified samples were dyed with disperse dye using carrier dyeing process. The presence of resin on the surface of fabric was confirmed using FTIR technique. Digital image processing (DIP) method has shown the resin treated fabric surface became smoother than untreated cotton fabric. ANOVA study indicated that there was a strong relationship between resin percentage on fabric and colour value (K/s). The colour durability of dyed samples was also studied. These samples were also analyzed for tensile, tear, crease recovery angle and colour fastness properties.

Keywords: *ANOVA, Colour value, Digital image processing, FTIR, Resin Water Conservation*

1. Introduction

The wet processing of cotton fabric is long and complex which consume a huge amount of water, energy and textile auxiliaries which increase the effluent load on the environment [1-2]. The demand of fresh water is expected to increase by 40 percent worldwide by 2030. Water is used in textile wet processing as a solvent for chemicals, dyes and washing [3]. According to USEPA a unit producing 20,000 Ib (9072 Kg)/ day of fabric consumes 36000 liters of water [4-5]. Approximately 80-100 liter of water is required to process just 1 kg of cotton fabric [6-9].

The environmental awareness and legislations force textile industry to adopt more sustainable processes in textiles. New developments are going on to reduce consumption of water in wet processing through various new approaches and automations in technology [10]. Surface modification of cotton fabric to enhance dye uptake and water conservation using various techniques like plasma treatment, laser treatment and cationisation has been used by various researchers [11-14].

In this study the surface of cotton fabric was modified using resin followed by dyeing with disperse dye without pretreatment of fabric. Thus water used in various pretreatments processes like desizing, scouring and bleaching can be saved by using this newly developed process. This can also lead to conserve chemicals, energy and cost in wet processing of cotton.

2. Material & Methods

Low molecular weight resin having good affinity with disperse dye was procured from local market. Low energy disperse dyes in two colours Foron Red RD-E and Foron Blue RD-E were procured from Archroma India Pvt Ltd. Dispersing agent, acetic acid and eco friendly carrier were procured commercially. Grey cotton fabric having 1/1 plain weave (Ends/inch: 86 and Picks/inch 74) was procured from the local industry.

2.1 Application of resin and dyeing:

Pre-weighted solid resin was dissolved in hot water with continuous agitation using magnetic stirrer. Six solutions of different concentrations of resin (20 gpl, 40 gpl, 60 gpl, 80 gpl, 100 gpl and 120 gpl) were prepared. The grey fabric sample was dip into the resin solution for 15 minutes and then passed through the nip of padding mangle at the speed of 3 m/min and 2 bar pressure to remove excess material. The fabric sample was again immersed in to the solution for 5 minutes and then passed through the nip of the padding mangle maintain same processing variables. The same process was repeated for all concentrations of resin solution. The treated samples were then dried at 105±3°C till constant weight and cured for one minutes at 150±3°C. These cured cotton fabric samples are coded as SMW20, SMW40, SMW60, SMW80, SMW100 and SMW120. Finally these treated samples and untreated cotton fabric (control sample) were dyed with 3% shade of disperse dyes at 90-95°C, maintaining pH around 5.5 with acetic acid in the presence of carrier. Dyeing is carried out in Lab model IR dyeing machine.

2.2 Characterization

2.2.1 FTIR analysis

Fourier-transform infrared (FTIR) spectra of resin, untreated and treated fabric were recorded on Perkin Elmer UATR TWO instrument using ATR method to confirm the presence of resin on treated fabric.

2.2.2 Digital image processing (DIP) method

DIP method was used [15, 16] for further analysis of treated (100Gg/l) and untreated cotton fabric. The fabric samples were scanned at 600 dpi and simulation graphs for roughness on surface were plotted using Matlab software. The images obtained were first inverted so that the lighter areas represented the densely populated part of the fabric and the dark parts – the sparsely populated region. The images were

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transformed to gray scale and then loaded into Matlab. To remove noise, Gaussian filters were applied. The degree of smoothening of surface of fabric was determined by the standard deviation of the Gaussian, which is generally taken as 5. The color of individual pixels was plotted as the height in the graph. As there is a difference between the color of different regions of the fabric, this causes a variation in the height of the plot. This difference is used to determine the surface roughness.

2.3 Statistical Analysis

The experimental data were analyzed using SPSS (version 20). The null hypothesis (H_0) states that there is no relationship between concentration of resin used for treatment and color strength of dyed fabric. An alternative hypothesis states the possibility of relationship between concentration of resin (g/l) and color strength of dyed fabric. H_0 is rejected if p value is less then pre- determined significance level which is ideally 0.05.

2.4 Durability of colour

Durability of surface colour was analyzed after 10 launderings of fabric. Fabric samples were washed as per ISO 6330 5A test method followed by line drying. For this purpose, colour strength of dyed samples before and after wash was determined with Macbeth Color Eye 3100 under the illuminant D65 using 10° standard observer. The K/S values were determined using expression;

$$K/S = \frac{(1-R)^2}{2R}$$

where, R is the reflectance at complete opacity, K is the Absorption coefficient & S is the Scattering coefficient

2.5 Analysis of fabric properties

Colour fastness test to washing was done by the standard method IS/ISO -105-C10A (1): 2006(E). The shade change, together with staining of adjacent fabrics, was rated according to appropriate SDC grey scales. Colour fastness to rubbing was carried out as per IS 766 and colour fastness to light was carried out by IS 2454. The tensile strength of all samples was measured in as per the IS1969 method. The tear strength was measured using IS 6489 test method. The crease recovery angle was measured as per IS 4681.

3. Result and discussion

3.1 Dyeing

All the resin treated fabric samples (SMW20, SMW40, SMW60, SMW80, SMW100 and SMW120) along with untreated cotton fabric (Control sample) were dyed using disperse dyes in two colours - Foron Red RD-E and Foron Blue RD-E. After dyeing, uniform surface dyeing effect was obtained. Colour strength values (K/S) of all the dyed samples (Control, SMW20, SMW40, SMW60, SMW80, SMW100 and SMW120) are shown in Fig.1. From the fig.1 it can be observed that colour strength of dyed fabric increases with increase in treatment concentration of resin. From the figure t is clear that there is no significant increase in add-on% after 100 g/ l which indicates arrival of saturation stage of resin present on the surface of fabric. Therefore 100g/l treatment concentration of resin on cotton fabric is selected for further study. Fig. 1 also depicts the actual add-on % of resin on the fabric after treatment with different concentration of resin. In the case of control fabric, only tint of colour was observed.

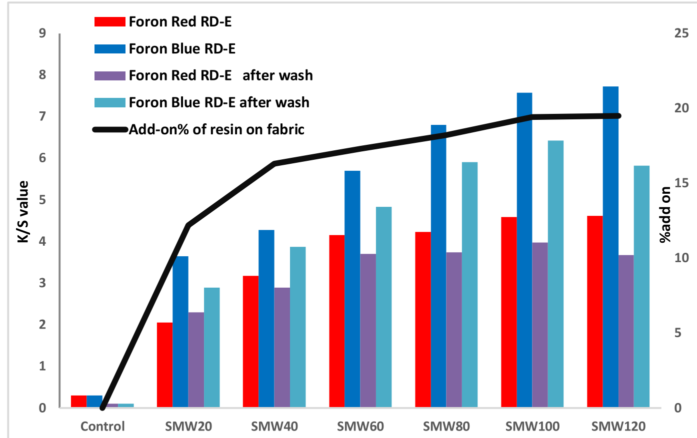

Figure 1: Add-on% and K/s Value of dyed and washed samples

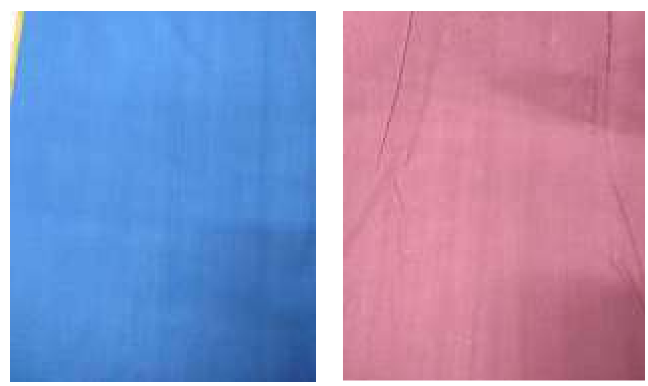

Figure 2: Solid shade on cotton using disperse dye (Sample SMW100)

3.2 FTIR analysis

The FTIR spectra of untreated cotton fabric (control), resin treated cotton fabric (SMW100) and resin is shown in Fig 3. The untreated cotton fabric exhibited a number of FTIR spectra absorption features. It can be observed that treated cotton fabric consist all the peaks of untreated cotton fabric. The broad peak centered around 3360 cm^{-1} in both the fabrics, represent characteristics of -OH functional group present in cotton in the form of cellulose. A broad peak was also observed at 3000–2800 cm^{-1} region indicates C– H stretching. A strong adsorption band with a maximum at 1030 cm^{-1} is a result of the overlapping bands attributed to functional groups of cellulose, namely the C–C, C–O and C–O–C stretching vibrations. The peak in treated fabric and resin samples between 1750 – 1735 cm-1 attributed to ester C=O stretch which confirms the presence of resin on the cotton fabric.

3.3 Colour Durability:

The colour durability properties of dyed fabric samples were determined in terms of colour retention (K/S value) after 10 launderings. The results are shown in Fig 1. From the fig.1 it

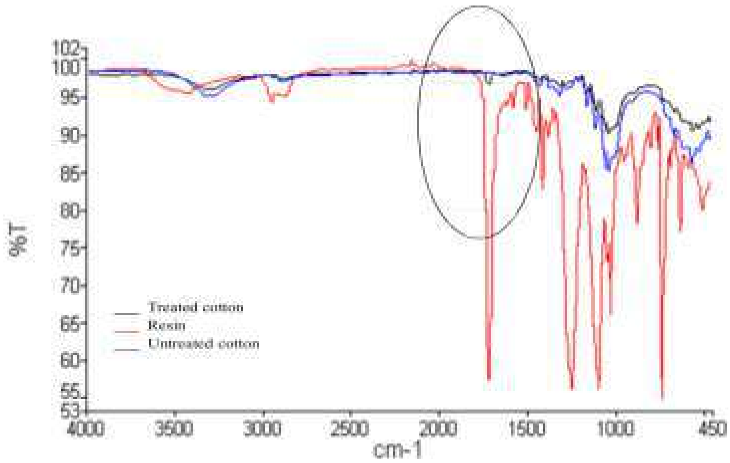

Figure 3: FTIR Spectra of treated cotton fabric, untreated cotton fabric and resin

is clear that there is a reduction in colour values of all the samples after 10 launderings. It was observed that the loss of colour after laundering found to be increased when concentration of resin increased from 20% (SMW20) to 120% (SMW120). The loss in colour after washing in a fabric dyed with Foron Red RD-E colour was found to be 7% and 20% for SMW20 and SMW120 fabric samples respectively. Similarly in the case of fabric dyed with Foron Blue RD-E, the loss in colour after launderings was found to be 8% and 25 % for SMW20 and SMW120 fabric samples respectively. This study indicated that at higher percentage of resin, chances of colour washed out will be more. On the other hand there is almost washed out of colour in the case of control dyed sample after 10 launderings.

3.4 Digital image processing method

Digital image processing methods were used to obtain surface plots for untreated and treated cotton fabric (SMW100). These plots are shown in Fig. 4 (untreated cotton fabric) and Fig 5 (treated fabric). The untreated cotton fabric sample had a greater numbers of peaks with greater peak heights (Fig. 4) than resin treated fabric samples (Fig. 5). The surface of the untreated cotton fabric was rougher than that for the treated fabric sample. The image of treated fabric shows very less variation in height of plot as compare to untreated fabric which can be attributed to smoothness of fabric surface because of resin treatment. The roughness of untreated fabric was reduced by resin treatment of fabric.

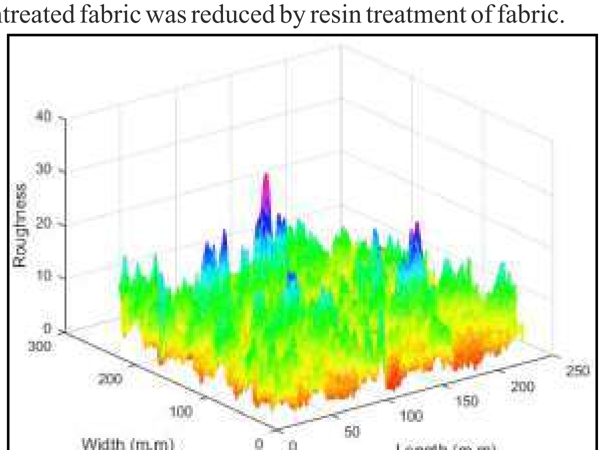

Figure 4: Digital Image of Untreated cotton Fabric

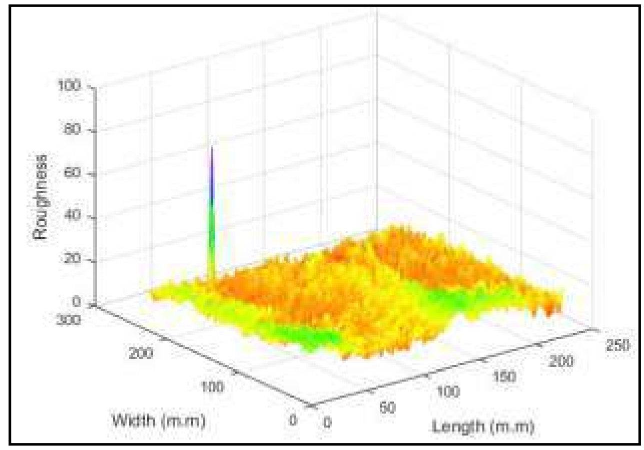

Figure 5: Digital Image of Treated Fabric

3.5 Statistical Analysis: The ANOVA results for studying the relationship between resin concentration and colour strength (K/S) of blue and red colour dyed samples are shown in Table 1 and Table 2 respectively. The null hypothesis (Ho) was rejected p-value was less than a pre-determined significance level (0.05). The regression coefficient (R^2) values of blue and red colour dyed cotton fabrics were found to be 0.974 and 0.964 respectively, which indicated a very strong relationship between the resin concentration and colour strength.

Table 1: ANOVA among % of resin concentration and colour strength (K/S value) of blue colour dyed fabric

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	419.699[a]	6	69.950	152454.520	.000
Intercept	1853.455	1	1853.455	4039579.841	.000
Concentration, gpl	419.699	6	69.950	152454.520	.000
Error	.029	63	.000		
Total	2273.183	70			
Corrected Total	419.727	69			
a. R Squared = 0.974 (Adjusted R Squared = .971)					

Table 2: ANOVA among % of resin concentration and colour strength (K/S value) of red colour dyed fabric

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	161.018[a]	6	26.836	285.162	.000
Intercept	780.625	1	780.625	8294.874	.000
Concentration, gpl	161.018	6	26.836	285.162	.000
Error	5.929	63	.094		
Total	947.572	70			
Corrected Total	166.947	69			
a. R Squared = .964 (Adjusted R Squared = .961)					

3.6 Colour fastness properties

The colour fastness to washing, rubbing and light properties of SMW100 fabric and control are shown in Table 3. From the table dyeing of untreated cotton fabric (Control) with disperse dyes, gives very poor colour fastness to washing, light and rubbing properties. However, treated cotton fabric (SMW100), gives satisfactory colour fastness properties.

Table 3: Colour fastness properties

Colour fastness properties	Control sample	Treated cotton fabric (SMW100)	
		Red colour	Blue colour
Colour fastness to washing			
- Change in colour	1	3-4	3-4
- Staining on cotton fibre	2	4-5	4-5
- Staining on polyester fibre	1-2	3	3-4
Colour fastness to light	2	3-4	3-4
Colour fastness to rubbing			
- Dry	1-2	4	3-4
- Wet	1-2	3	3

3.7 Physical properties

All the dyed fabric samples were evaluated for tensile strength, tear strength and crease recovery angle properties. The results of tensile and tear strength is given in the Table 4. These results were compared with grey cotton fabric (control sample). The tensile strength of control sample in warp direction was 481 N and weft direction was 515 N. The tear strength of control sample in warp direction was 791 N and weft direction was 801N. From the table it can be observed that as the concentration of resin on cotton fabric increases the tensile and tear strength decreases which may be attributed to the curing process used to cross link resin on cotton fabric [16].

Table 4: Tensile and tear strength of treated cotton

Sample code no.	Tensile strength,gf				Tear strength,gf			
	Red colour		Blue colour		Red colour		Blue colour	
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
SMW20	478	511	472	503	789	795	773	789
SMW40	464	494.6	470	492	761	783	758	784
SMW60	419.5	488.7	425.6	481.4	731	764	735	773
SMW80	405.7	468.9	401.5	470	710	747	702	747
SMW100	368.9	434.6	362.4	432.7	695	729	684	731
SMW120	353.6	403	346.8	406.5	678	708	679	714

Crease recovery angles of the treated samples for both the dyes were evaluated and shown in the Fig. 6 and it was found that crease recovery angle decreases as the concentration of resin on the fabric surface increases. This can be attributed to the stiffness of the fabric because of presence of the resin on the surface. Resin being a polymer prevents the crease to recover hence crease recovery angle decreases.

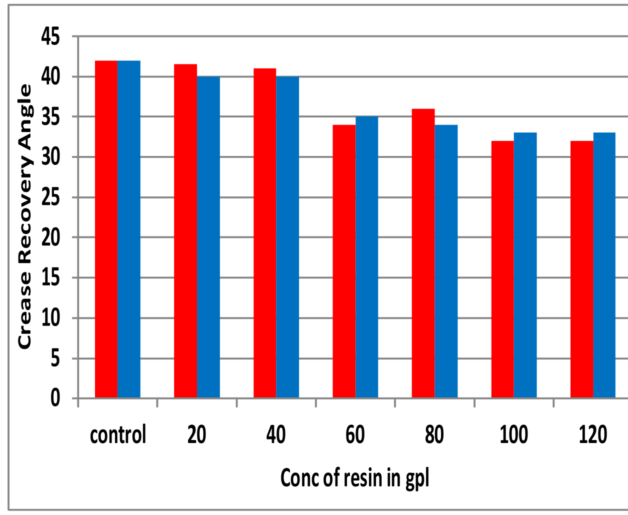

Figure 6: Crease recovery angle of treated cotton fabric

4. Conclusions

Six resin treated fabric samples were developed using 20g/l to 120g/l resin solutions. The FTIR spectra of untreated cotton fabric, resin treated cotton fabric and resin confirmed the presence of resin on treated fabric. The tensile strengths of treated fabrics decreased with increase in concentration of resin treatment. The tear strengths and crease recovery angles of treated fabrics decreased with increase in resin concentration. DIP showed that roughness of fabric sample was reduced by resin treatment.

These samples were dyed with two disperse dyes - Foron Red RD-E and Foron Blue RD-E. The uniform dyeing effect was found in all the dyed fabrics. It was observed that colour strength of dyed fabric increases with increase in treatment concentration of resin. The colour durability of dyed fabric samples was determined in terms of colour retention after 10 launderings. It was observed that the loss of colour after laundering found to be increased when concentration of resin increased.

The ANOVA clearly indicated that there was a very strong relationship between the resin concentration and colour strength as the regression coefficient (R^2) values of Foron Red RD-E and Foron Blue RD-E dyed cotton fabrics were found to be 0.974 and 0.964 respectively.

The colour fastness to washing, rubbing and light properties showed the untreated cotton fabric (Control) with disperse dyes, gave very poor colour fastness to washing, light and rubbing properties. However, treated cotton fabric shown satisfactory colour fastness properties.

Acknowledgement

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Thermal Comfort Properties of Soybean, Soybean & Polyester and Soybean & Wool Blended Plain-woven Fabrics Dyed with 1:2 Metal Complex Dyes

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Abstract

Textile industry is one of the oldest manufacturing industries and also one of the most polluting industries on the earth today. This industry produced 150 billion garments in 2015 out of which 60% of garments are synthetically derived like polyester. Hence, effort should be made to use more natural fibers and reduce the use of synthetic fibers for the sustainability of this industry. Therefore, this study is focused to use more sustainable fibers like soybean, wool with some polyester. The objective of this study is to develop more eco-friendly dyed fabrics produced from the different blend proportions of Soybean, Polyester and Wool fiber and to study their mechanical and comfort properties. In this study, two ply yarns were spun in ring spinning system with 100% Soybean, 65%–35% Soybean/polyester and 65%–35% Soybean/wool. Then plain-woven fabrics were produced from these yarns and further dyed with 1:2 metal complex dyes. Finally, the thermal comfort parameters were measured for these dyed samples. The results indicated that soybean possess low air permeability, water vapor permeability with their counterparts but moderate thermal insulation and excellent wicking behavior. The moderate comfort behavior and good dyeability with 1:2 metal complex dyes of soybean fibers and its blends has a great commercial potential in apparels.

Keywords : *Soybean, air permeability, thermal insulation, metal complex dyes, K/S value*

1. Introduction

Clothing is not merely the necessity of humankind but defines the personality of the wearer. The improvement of the economic status drives the demand to produce 150 billion garments in 2010 [1]. This projection of the production of apparels in terms of value will touch to $961.0 in 2021 with an increase of 28.5% since 2016 [2]. Gugnami and Mishra 2012 [3] estimated that 400 billion square meters of fabric produced in 2015 and 100 million tons of fibers were used to produce this huge volume of fabrics. The share of synthetic fibers (polyester, nylon) to produce this huge amount of garments was around 60%. The synthetic fibers mostly derived from the petroleum sources. Hence, this huge production of fabrics with synthetic fibers becomes a major contributor of Green House Gases. This huge quantity of fabric production also required a large amount of fresh water for processing [4]. Therefore, a more sustainable approach is required in every step of Textile and Apparel value chain. The first step to attain sustainability is to reduce the dependence on the synthetic fibers as well as to reduce the production level. The other challenge for the textile and apparel industry is also to produce long durable garments with better comfort. The key aspect of the clothing has been greatly influenced by the comfort characteristics of the constituent fabric of the garment. The fabric characteristics of the clothing are greatly influenced by the constituent fibers. The natural fibers like cotton, linen, wool and silk are the most used for the garments as well as the synthetic fibers like polyester, nylon, acrylic etc. The introduction of specific properties in synthetic fibers makes them more functional and can be used in varying seasons. The rising demand of synthetic fibers makes the textile and apparel industry unsustainable. Hence, efforts have been carried to use more modified natural fibers which are environmentally friendly as well as more functional [5]. The natural protein fibers are extensively used for garments and have decent physical properties. Garments made of protein fibers are expensive due to low availability and higher processing stages [6]. The soybean fibres are typical plant protein fibres and spun by the wet method spinning process from the natural soybean cake after extraction of oil from the soybean. The auxiliaries and agents used to produce soybean is non-toxic and complies the environmental standards. Moreover, the production process causes least waste generation [7]. The natural protein fibres also offer difficulty for processing as non-uniform profile and limited fineness. The dyeing of wool is also difficult due to the presence of the scales in wool. Therefore, soybean can become a potential replacement of the wool and silk as it can be drawn with unlimited fineness. Soybean fibers are inherently softer, lustrous and drapable. The soybean fibers are also offering decent amount of UV resistant, antibacterial, transmission property as well as good dyeability [8]. It also possesses many advantages over the other fibers like moderate breaking strength, modulus, and low shrinkage in boiling water. The effective blending of soybean fibers with other fibers (polyester, wool, silk) will help to achieve various functionalities, yarn properties and to reduce the cost. The good quality garments must have decent aesthetic value, physical and mechanical properties as well as thermal comfort. Thermal comfort is the basic ability of the garment for the transmission of air, moisture, and heat. The transmission rate varies with the external environment as well as with the activity level [9]. Onofrei E et. al. [10] reported that the comfort parameters such as air permeability, thermal resistance and thermal absorptivity properties of

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fabrics produced from the soybean, cotton and seacell blended fabrics are significantly affected by the blend ratios.

Although there are many studies have been found on the comfort performance assessment of gray fabrics of soybean and its blend, but few literatures have been found for the dyed soybean samples. The optimum conditions for pretreatment and dyeing are a major problem for the commercial success of these new generation eco-friendly fibers. Hence, in the present investigation, three 1:2 metal complex dyes (Lanaset Yellow 2R, Lanaset Blue 2R and Lanaset Red 2B by Huntsman corporation) have been applied on the soybean blended fabrics and the comfort performances of these dyed samples of different blends of soybean have been assessed.

2. Materials and Methods

2.1 Materials

In this study, soybean, polyester and wool fibers were selected as yarn components. The mean fiber length and fineness of the sourced soybean were 40mm and 1.5 denier. The mean fiber length and fineness of the polyester fibers were 44mm and 1.4 denier whereas the wool fibers had a mean fiber length of 44 mm and the micronaire value of 22.5micron. Two ply yarns of 100% Soybean, 65%–35% Soybean/polyester and 65%–35% Soybean/wool yarns were spun on traditional ring spinning system and doubled by a two for one twister machine. These yarns then woven into 1/1 Plain fabrics using a sample rapier loom. The areal densities (grams/meter^2) of all the three fabrics were kept similar for easy comparison. The yarn and fabric constructional parameters are shown in Table 1. The fineness of the wool was measured as per IS5911:1977.

Table 2.1: Yarn and fabric constructional parameters of the samples

Sample	Blend %	Yarn Linear Density Tex	TPC[1]	Hariness[2]	Areal Density Gram/m^2	Thickness mm	Porosity %
Soybean	100	19.7	7.5	159	170	0.48	72.56
Polyester/ Soybean	65/35	19.7	7.5	74	167	0.45	73.12
Polyester / Wool	65/35	19.7	7.5	62	160	0.55	79.27

[1]TPC-Twist per centimeter (ASTM D1423M-16), [2]Hariness - Number of hairs above 3mm/200meter.

2.1.1 Pre-treatment and Dyeing Procedure

To remove any dirt and impurities from the fabric, first soybean fabric was scoured for 1 hour with bath containing 2g/L soda ash and 2g/L non-ionic detergent at mass to liquor ratio at 1:30 for 90 minutes at 70^{0}C temperature and pH kept at neutral. The fabric was then washed thoroughly. The oxidative alkaline bleaching was done with 15 mL/L hydrogen peroxide, 4 g/L Stabilizer AWNI at pH 10 and temperature 90°C for 60 min. The pH was finally brought to neutral with acetic acid. Similar scouring and bleaching treatment were given to wool as well but at the temperature of 50°C [10].

Soybean fiber typically protein fibers can be dyed with a wide range of dyes under acid, neutral, or slightly basic conditions. Acid dyes and mordant dyes may be rendered very fast by mordanting with metal salts; chromium salts are especially effective as mordants. At neutral or slightly acid pH, protein fibers may be dyed with cationic or basic dyes; however, the fastness of the dyed fiber is poor without mordanting with tannic acid or other mordants for cationic dyes [11]. Hence, 1:2 metal complex dyes were trialed in this study to observe the suitability for soybean fibers. These three fabrics samples were dyed with 1:2 metal complex dyes of Lanaset Yellow 2R, Lanaset Blue 2R and Lanaset Red 2B (commercial dye sourced from Huntsman cooperation). The dyeing was carried out in a roto-dyer. The dye bath of the roto-dyer was set to 40^0 C and MLR (material to liquor ration with mass) was kept at 1:40. Then fabric was treated with 4% ammonium sulphate and 1% levelling agent (Uniperol SE, BASF) for 10 minutes then required amount of acetic acid was added to get pH a 4.5-5. After that dye was added and dye bath was heated to 90^{0}C and held at this temperature up to 60 minutes. The dyed samples were soaped mildly with non-ionic detergent (2 grams per liter) and then washed with cold water and dried.

2.2 Testing Methods

The prepared fabric samples were conditioned at standard testing conditions (20 ± 2 °C, 65 ± 2% RH) for 24 h in accordance with ASTM D1776 / D1776M-16 [12]. The air permeability, vertical wicking, multidirectional liquid moisture transmission properties, and thermal and water vapor resistance of the fabrics were measured so that the thermal comfort properties of the produced fabrics could be determined. The color yield (K/S) values, washing fastness and FTIR (Fourier Transform Infra-Red) spectroscopy were conducted for the samples to analyse the dyeing behavior with the 1:2 Metal Complex dyes.

The yarn linear density, twist per centimeter and the hairiness values were determined and presented in the Table 1. Yarn hairiness is the amount and length of fiber ends or loops that protrude from the yarn body. The numbers of hairs which are protruded beyond 3mm were counted in 200 meters of yarn length [13]. The hairiness values were determined using Zweigle G-565 tester.

Air permeability tests of these fabrics were tested on Profilic air permeability tester according to ASTM standard D737-96 [14]. The exposed area of test specimen was 10 cm^2 under the pressure drop of 10mm of water column. Water vapour transmission rate of fabric was measured on W3/060 according to ASTM standard E96 [15]. Thermal insulation of fabric was measure on Alambeta tester which measures transient thermal characteristics of textile fabrics and the thermal resistance value is expressed in m^2K/W. The vertical wicking test of the fabric was carried out according to the AATCC TM195-2012 standard [16]. The conditioned sample of 20cm x 2.5cm was cut both along the direction of warp and weft. A setup was installed which had a ring holder were in the fabric was hanged vertically. A beaker having colored solution of 2gpl cold brand reactive dye was taken. Each specimen was marked with a line 3cm away from its edge along its length. The specimen was then dipped inside the solution till the mark and wicking height was noted down after an interval of 5min, 10min, 15min and 30min. In addition to this, the porosity [17] of these fabrics is determined as per Equation 1.

$$\text{Porosity Equation} = (1 - \frac{m}{h}) \times 100 \text{ -----------(1)}$$

where P is the porosity in percentage, m is the fabric areal density, ρ is the fiber density in g/cm^3 and h is the fabric thickness in mm. The fiber density value in the equation is calculated by taking the individual fiber densities and blend ratios into consideration. The calculated values of the fabric porosity are shown in Table 2.1.

The K/S values were determined by using a spectrophotometer (Premier Colorscan SS 5100A). The wash fastness was measured by using a Lauderometer with a standard multifiber strip as per ASTM D5548 [18]. The samples were also tested for FTIR (Fourier Transform Infra-Red) spectroscopy using Brucker tabletop model based on ATR principle. The peaks were obtained by Attenuated Total Reflection (ATR).

3. Results and Discussion

The results of thermal comfort parameters such as air permeability, water vapor transmission rate, thermal resistance and vertical wicking values are shown in Table 3.1.

Table 3.1: Thermal comfort parameters of the experimental fabrics

Fabric Types	Air permeability (m^3/m^2min.)	Thermal resistance (m^2k/W)	Water vapor transmission rate (g/m^2.day)	Wicking Height (cm)	
				Warp	Weft
100% Soybean	91.68	21.2	6978	16.8	16.3
65-35% Polyester/ Soybean	133.36	19.6	7834	16.4	15.8
65-35% Polyester/ Wool	158.37	26	8112	14.5	13.5

3.1 Thermal Comfort Properties

3.1.1 Air Permeability

Air permeability is an important comfort property which indicates the amount of air passed through the fabric unit area. This is a very important thermal comfort parameter as it helps to balance the flow of air from environment to human body and vice versa. The air permeability depends on fabric porosity, which affected by the number of pores in the textile fabric, yarn linear density i.e., yarn diameter, yarn hairiness, fiber cross-section and shape. The pores in the fabric are affected by the hairs as the hairs significantly blocks these pores affecting the air permeability. The results showed that the air permeability of Polyester/Wool blend exhibits highest value of air permeability while Soybean shows lowest value whereas the Polyester/Soybean exhibits intermediate values. The 100% soybean fabric shows lowest value of air permeability due to more yarn hairiness, lower porosity values as shown in Figure 3.1. The lower value of porosity causes lower air passage and vice-versa. Air permeability also decreases with more protruding hairs as it hinders the passage of air through the fabric pores.

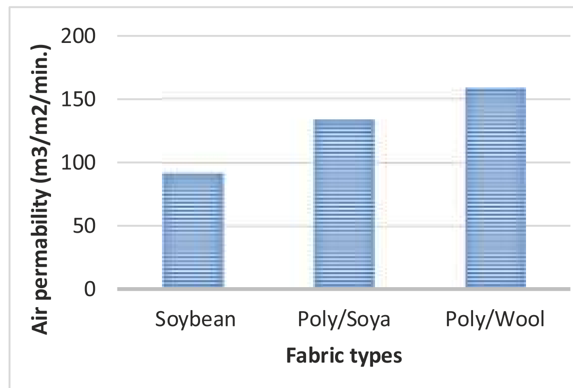

Figure 3.1 – Comparative analysis of air Permeability values of different types of fabrics

3.1.2 Water Vapor Transmission Rate

The water vapor transmission rate is another important parameter of thermal comfort which helps to transport the sweat from the skin for the comfortable feeling. Water vapor transmission rate is a measure of the passage of water vapor through the material. It is the mass of water vapor transmitted through a unit area in a unit time under specified conditions of temperature and humidity. The water vapor permeability depends on the several factors like fabric constructional parameters, fabric pores and type of constituent fiber. It is observed from the Figure 3.2 that the Polyester/wool fabric exhibits highest water vapor transmission rate while Soybean fabric shows lowest water vapor transmission rate and Polyester/Soybean fabric exhibits values in between them. Soybean fabric shows lowest water vapor transmission which may be due to more yarn hairiness and higher value of cloth cover. The higher hairiness value of the constituent yarn of the fabric provides hindrance to water vapor to pass through the fabric due to which water vapor transmission rate decreases at higher hairiness. Polyester/Wool exhibits highest value of water vapor transmission rate due to structure of wool. The outer sheath i.e. epicuticle of the wool has tiny microscopic pores, through which water vapor may penetrate into the internal structure of the fiber. The outer sheath helps wool fabric to absorb water vapor & release into air.

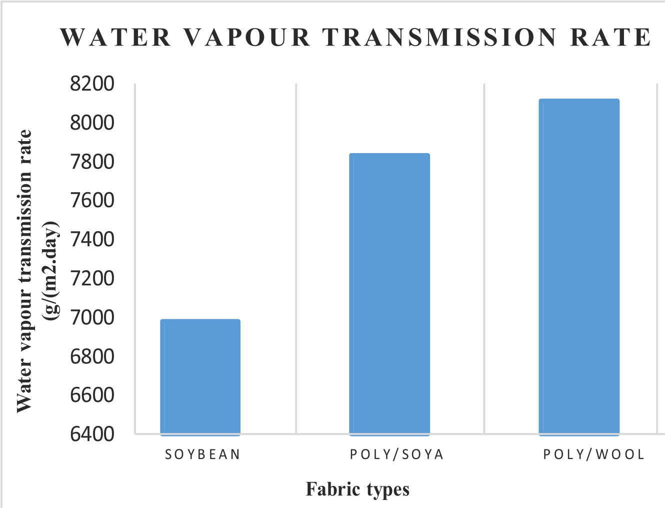

Figure 3.2: Comparative analysis of Water Vapor Transmission Rate of experimental fabrics

3.1.3 Thermal Resistance

Thermal resistance is an important measure for analyzing the effect of material properties on heat transfer. Thermal resistance is a measure of a materials ability to prevent heat from flowing through it. It is a very important parameter and is greatly influenced by fiber type and fabric thickness. Figure 3.3 depicts that Polyester/wool fabric exhibits highest value of thermal resistance while Polyester/soybean fabric shows lowest value of thermal resistance and Soybean fabric exhibits value of thermal resistance in between them. Increase in the fabric thickness will result in increase in thermal resistance. Because of crimp and felting property wool fiber makes the fabric bulky and lofty so Polyester/wool fabric has highest thickness among the three fabrics hence shows highest thermal resistance.

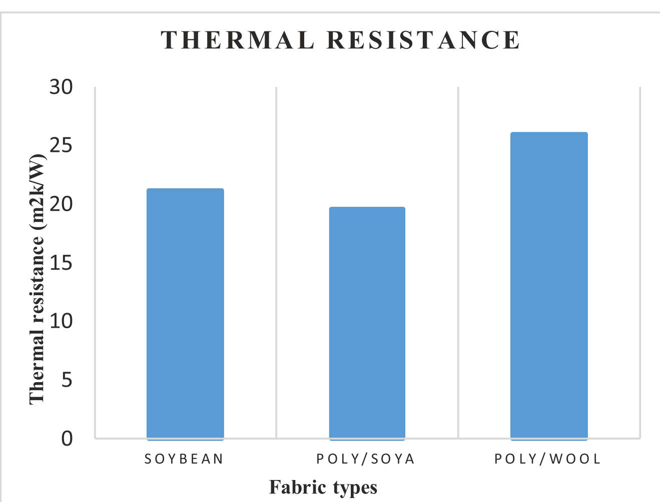

Figure 3.3 – Comparative analysis of Thermal resistance of experimental fabrics

3.1.4 Wicking Behavior

Wicking is the spontaneous flow of a liquid in a porous substrate, driven by capillary forces. It is an important factor in determining the comfort of clothing for active wear. High wickability facilitates quick drying and fast cooling in hot environments. The wickability results of the tested fabric samples are given in Figure 3.4. It is observed that the 100% soybean fabric exhibits highest wicking height in warp & weft direction while Polyester/Wool fabric exhibits lowest wicking height in warp way and weft way. Polyester/Soybean fabric exhibits in between wicking height in warp & weft direction. It is found that the wicking height depends upon yarn hairiness as the higher hairiness causes higher yarn diameter therefore provides more capillary spaces which helps to achieve more wicking. The adjacent protruding fibers are also participating as the inclined capillary. As the hairiness decreases the yarn become compact and hence there are fewer capillaries for wicking which causes less wicking height.

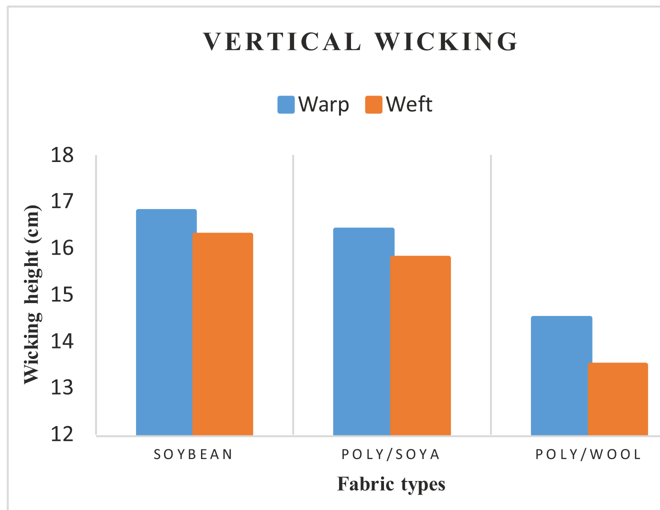

Figure 3.4 – Comparative analysis of Wickability of experimental fabrics

3.2 Dyeing Behaviour

3.2.1. Color Strength (K/S)

K/S value of 1:2 metal complex dyed fabrics with three different colors in different shade depths is shown in Figure 3.5. The result indicates that K/S value of Soybean fabric is highest and for Polyester/Wool K/S value is lowest. Polyester/Soybean fabric exhibits in between value of K/S. To an extent, soybean fiber has slightly higher K/S value than wool fiber because acidic amino acids (glutamic and aspartic acid) are in much higher amounts in soybean than in wool that increases number of dye fiber interaction points which may attribute to slightly darker shade in Polyester/Soybean blended fabric. Due to the presence of scales on wool surface results in difficulties in dyeing on the other hand soybean has smooth surface may be another reason for slightly higher K/S value in Polyester/Soybean. K/S value of 1:2 metal complex dyes increased as dye concentration increased. Lanaset Red 2B dye gave maximum K/S values in most cases which could be due to better dye absorption and penetration of dye in the fiber surface.

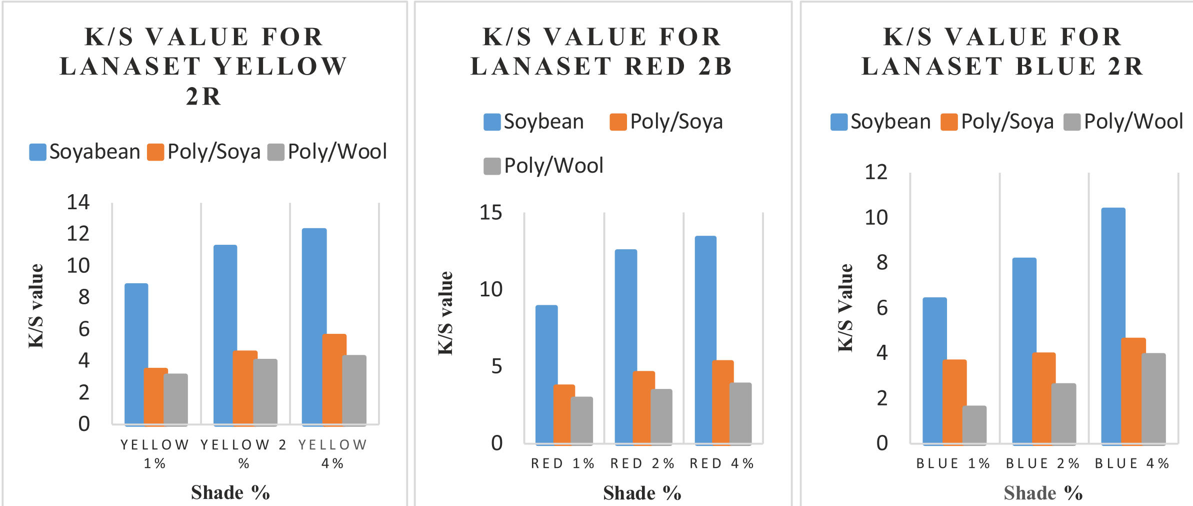

Figure 3.5: K/S value experimental fabrics dyed with (a) Lanaset Yellow 2R (b) Lanset Red 2B and (c) Lancet Blue 2R

3.2.2 Wash Fastness

The wash fastness of each sample dyed with the 1:2 metal complex dyes was assessed, and the results are Table 3.2. The staining of adjacent multifibres by the soybean blended fabrics was found to be of grade 4 or better. This cross-staining indicate that the metal complex dyes have more dye affinity for protein fibers. Soybean fabric exhibits good washing fastness properties because of strong coordinate bond formation between the fiber and metal complex dye molecules.

Table 3.2: Comparative assessment of the washing fastness of the experimental fabrics

Fabrics	Lanaset Yellow 2R			Lanaset Red 2B			Lanaset Blue 2R		
	1%	2%	4%	1%	2%	4%	1%	2%	4%
100% Soybean	4	4	4-5	4-5	4-5	4	4	4	4
65-35% Polyester/Soybean	3-4	3-4	3	3-4	3	3	3	3	3
65-35% Polyester/Wool	3	3	3	3	3	3	3	3	2-3

3.2.3 FTIR (Fourier Transform Infra-Red)

The Soybean, Polyester/Soybean and Polyester/Wool blended fabric were tested for IR spectra. The spectra obtained (Figure 3.6) for three fabric similar from 4000 to 1800cm^{-1}while subsequently their peaks significantly differ. This is indicative of the variation in structure and composition between regenerated protein and natural protein fiber blended with synthetic fiber. All three union fabrics were dyed with 1:2 metal complex dyes in 4% shade and tested for IR spectra. However, no significant changes in peaks were observed for these dyed samples except a little variation in peak intensities at places (Figure 3.7). This indicates that no major change in functional group or strength properties have occurred in the fabrics after the preparatory process and subsequent coloration carried out.

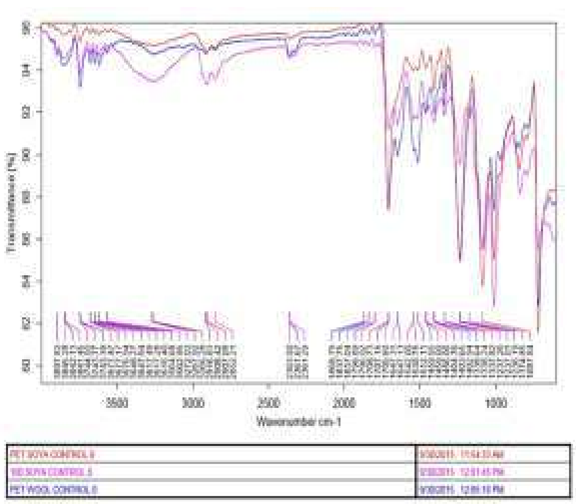

Figure 3.6: FTIR of Untreated Samples

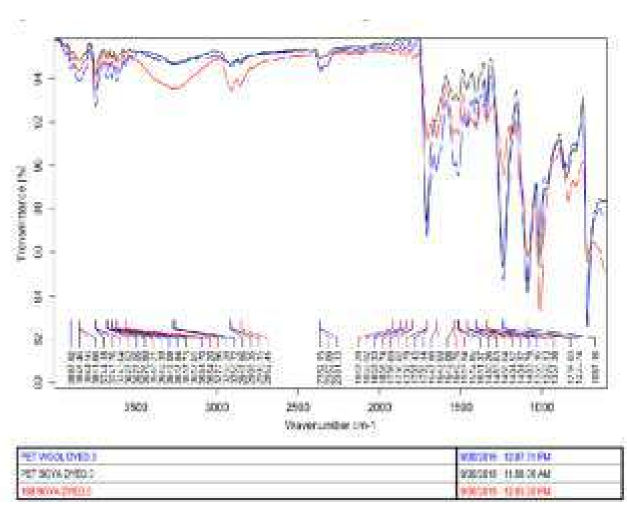

Figure 3.7: FTIR of Dyed Samples

4. Conclusions

In this study, the comfort properties of plain woven dyed fabrics with 100 % Soybean and two different blends of soybean such 65%-35% Soybean and Polyester and 65%-35% Soybean and Wool were investigated and the following observations are noted.

From thermal comfort point of view Soybean fabric shows the lowest air permeability and water vapor transmission rate due to more yarn hairiness as hairs provide hindrance to air flow while Polyester/Wool fabric shows highest value of air permeability and water vapour transmission rate due to less yarn hairiness.

Polyester/wool fabric shows highest value of thermal resistance due to higher thickness and Polyester/Soybean fabric exhibits lowest thermal resistance due to lowest thickness while 100% Soybean shows value in between them.

Soybean shows highest vertical wicking in both warp and weft direction due to highest yarn hairiness. At higher hairiness, the yarn diameter is more and there are more capillary spaces hence more wicking. Polyester/Wool fabric shows lowest wicking while Polyester/Soybean fabric shows intermediate values.

To an extent, soybean fiber has slightly higher K/S value than wool fiber because acidic amino acids (glutamic and aspartic acid) are in much higher amounts in soybean than in wool that increases number of dye fiber interaction points which may attribute to slightly darker shade in Polyester/Soybean blended fabric.

In FTIR no significant changes in peaks were observed for these dyed samples except a little variation in peak intensities at places.

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Studies on Effect of Weave Structures on Properties of Fabric

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Abstract

This paper aims to investigate the relationship between different fabric weave structure and its properties. In this connection, seven different basic weaves, as well as derivatives of basic weave structure, were studied. Properties of fabric in terms of areal density, thickness, air permeability, drapability, stiffness, and wicking were determined. It was found that satin weave exhibited higher areal density and maximum thickness. The woven fabrics with plain weave structure had the lowest air permeability, lowest drapability and highest stiffness.

Keywords-: *air permeability, comfort, drapability, fabric structure, weaves, etc.*

1. Introduction

Woven textiles are designed to meet the requirements of their end-use. Their areal density, thickness, air permeability, drapability, stiffness, and wicking can be varied and depend on the weave used, the thread spacing, that is the number of threads per centimeter, and the raw materials, structure (filament or staple), linear density and twist factors of the warp and weft yarns [1]. From woven fabrics, higher strengths and greater stability can be obtained than from any other fabric structure using interlaced yarns [2]. Structures can also be varied to produce fabrics with widely different properties in the warp and weft directions [3]. The property of any fabric produced depends on the constituent fibres material, yarns and the fabric structure. Also all these factors interact with each other [4]. The ultimate aim of any apparel fabric is to satisfy the wearer and make him feel comfortable. Hence, in the context, it is worth to study the fabric properties of different woven fabrics [5].

2. Material and Method

2/80 Ne cotton yarn was used in the warp for all he samples, and three weft yarns viz. 2/80 Ne cotton, cotton-polyester and polyester were used for manufacturing of fabric. Before manufacturing the fabrics, all yarns were tested for tensile properties, evenness, hairiness and twist level, and the test results are shown n Table 1. Seven different basic weaves as well as derivatives of basic weave structure viz. Plain, 2/2 matt, warp rib, 3/1 Twill, Herringbone twill, 8 end satin and crepe were manufactured on rapier weaving machine keeping 2:1 setting ratio (i.e. 120 epi and 60 ppi). Finishing was followed after fabric manufacturingwith normal process sequence as followed in the shirting industry. Finished fabric specimens were evaluated for areal density, thickness, air permeability, drapability, stiffness, wicking and drop absorbency under standard atmospheric condition

3. Results and discussion

3.1 Areal Density

The areal density of the woven fabric was calculated in terms of fabric GSM. The GSM of the fabric depends on its fabric

Table 1: Yarn properties

Sr. No.	Yarn Characteristics	Cotton	Cotton / Polyester	Polyester
1	Count (Ne)	42.14	42.3	44.29 (120D)
2	Tensile Strength (g/tex)	16.82	24.65	26.37
3	Elongation (%)	3.45	7.57	14.95
4	Hairiness Index	3.1	4.54	NA
5	Unevenness	7.63	10.82	NA
6	Twist Per Inch	27.2	22.3	NA

structure, yarn count, etc. Figure 1 shows the areal density of grey and finished fabrics. Figure2 exhibits the effect of weave, weft type and finishing treatment on the areal density of woven fabrics. It can be clearly seen from Figure 1 that there is a significant effect of a weave on the areal density of the fabric. The fabric sample woven with satin weave exhibits higher areal density followed by other weaves. This may be due to high float length in satin weaves. The plain weave sample showed minimum areal density. This is due to the higher number of interlacements and lower number of floats. After satin weave the gsm of herringbone twill was found to be higher followed by twill, crepe and plain weave derivatives i.e. matt and warp rib respectively. Higher the float length, higher will be the areal density of the fabric.

The fabric sample produced with polyester weft exhibits a higher areal density of fabric irrespective of weave and chemical treatment. GSM of fabric produced by cotton weft was found to be at a lower side than that of polyester and p/c blended weft fabrics. This is due to the higher linear density of the polyester yarn and lower linear density of a cotton yarn. But the effect of type of weft on the fabric GSM was not found to be significant. After finishing there is increase in fabric GSM. One of the reasons behind this phenomenon was, during the chemical finishing process, there is a deposition of several chemical materials on the fabric surface increasing the weight of the fabric. On the contrary unfinished product contains many impurities like dirt, wax, etc. which was removed by chemical treatment of grey goods. Due to this fact, there is a reduction in fabric weight after finishing. Due to these two opposing phenomena's occurring, though there is a marginal increase in fabric

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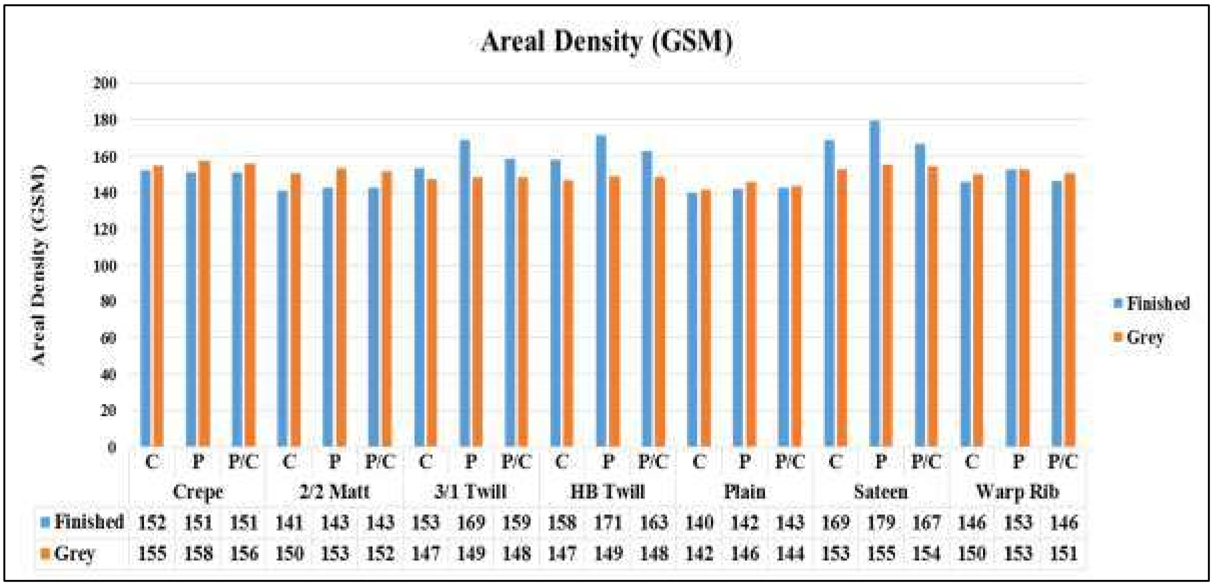

Figure 1:Areal density of grey and finished fabrics

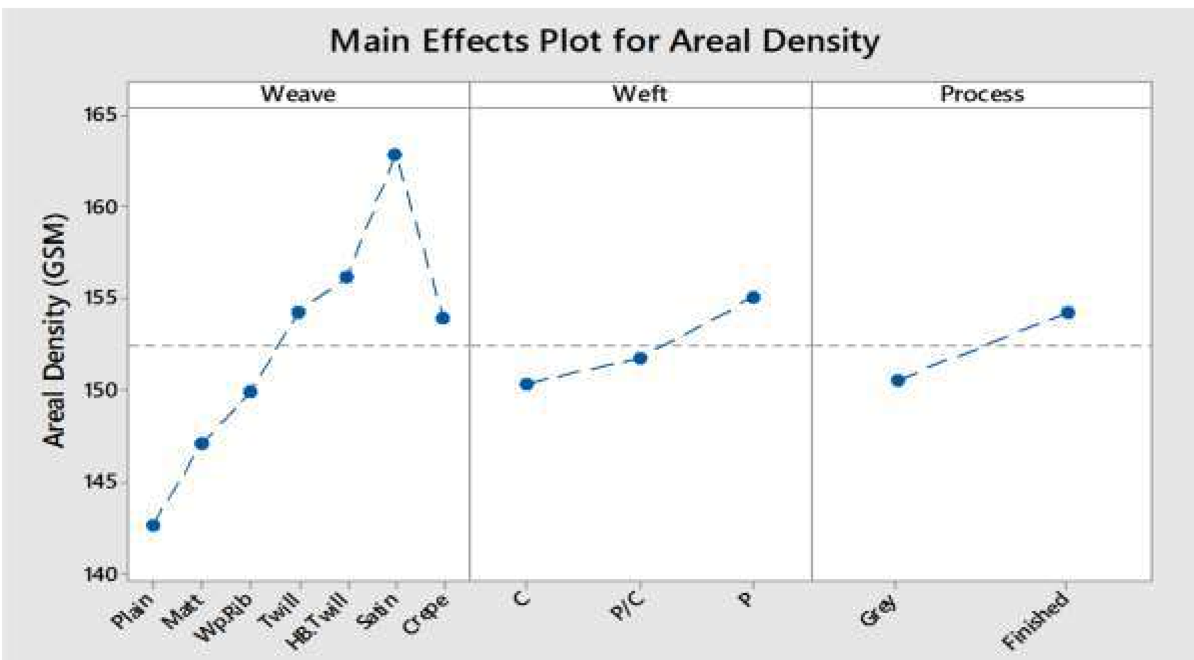

Figure 2: The effect of weave type, weft and processing on the areal density of the fabric

The fabric sample produced with polyester weft exhibits a higher areal density of fabric irrespective of weave and chemical treatment. GSM of fabric produced by cotton weft was found to be at a lower side than that of polyester and p/c blended weft fabrics. This is due to the higher linear density of the polyester yarn and lower linear density of a cotton yarn. But the effect of type of weft on the fabric GSM was not found to be significant. After finishing there is increase in fabric GSM. One of the reasons behind this phenomenon was, during the chemical finishing process, there is a deposition of several chemical materials on the fabric surface increasing the weight of the fabric. On the contrary unfinished product contains many impurities like dirt, wax, etc. which was removed by chemical treatment of grey goods. Due to this fact, there is a reduction in fabric weight after finishing. Due to these two opposing phenomena's occurring, though there is a marginal increase in fabric weight after finishing, the effect is not a significant one.

3.2 Thickness

Thickness is one of the major properties of the fabric to be considered because most of the comfort properties of final goods were influenced by this. Inpractice, the thickness measurements are rarely used as they are very sensitive to the pressure used in the measurement. Figure 3 shows the thickness of the grey and finished fabrics. Effect of weave type, weft material and chemical processing on the thickness of fabrics is as shown in Figure 4.

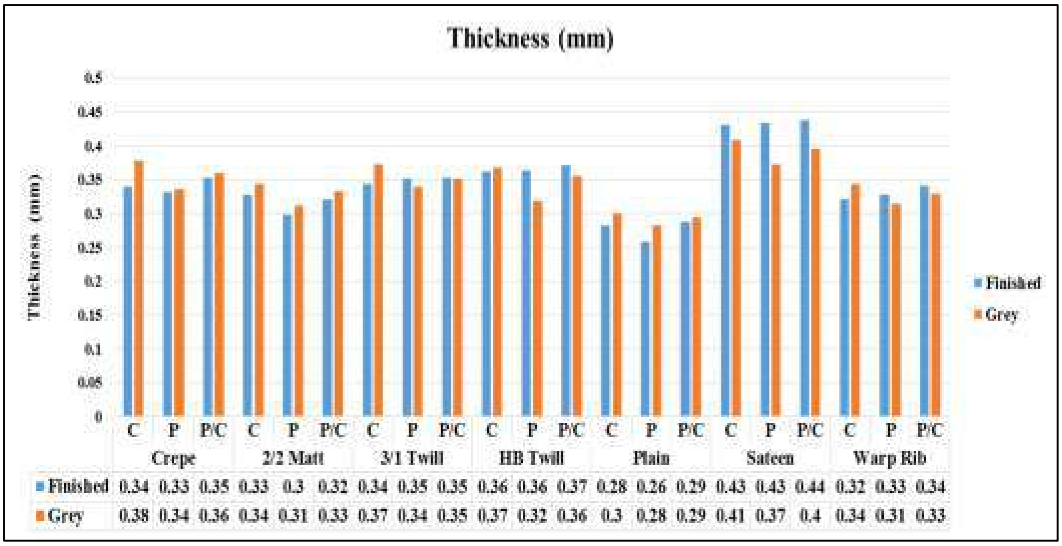

Figure 3:Thickness of grey and finished fabrics

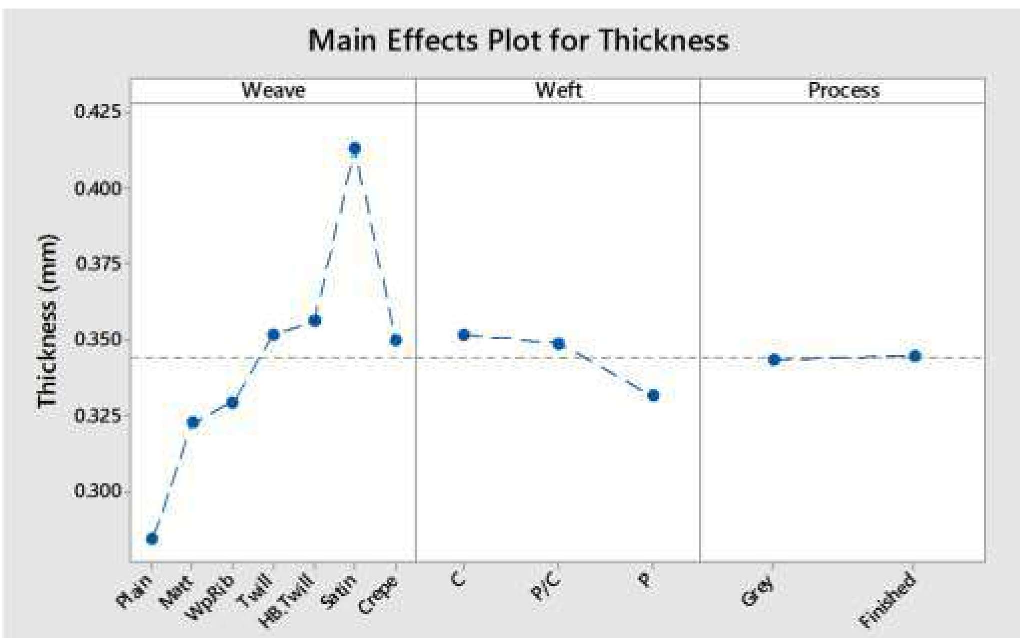

Figure 4:The effect of weave type, weft and processing on the thickness of fabric

It can be observed from Figure 4that fabric thickness varies significantly with weave type. The plain weave sample showed minimum thickness compared to other weave fabric. Satin fabrics showed maximum thickness due to the bulging effect caused by the floats followed by twill and plain fabric derivatives. The thickness of the fabric is mainly attributed to its float length. Due to the short float length of plain weave, its thickness is lowest amongst other weaves. After satin weave, fabrics with herringbone twill reports higher thickness followed by twill, warp rib, matt and crepe weave. Longer the floats, greater will be the bulging effect, thicker will be the fabric.

Fabric produced by polyester weft exhibits lower thickness value due to the compact nature of the polyester yarn and less hairiness of polyester yarn. Cotton yarn is bulkier in nature than polyester yarn and the hairiness of cotton yarn ismore than that of p/c blended yarn and polyester multifilament yarn. Hence fabrics produced using cotton yarn have higher thickness followed by p/c blended yarn. Finishing treatment has no significant effect on fabric thickness.

3.3 Air Permeability

Air permeability is a critical parameter of clothing, as it contributes to the comfort level of the wearer. It influences the flow of the vapour from the human body to the environment and the flow of fresh air to the body. It is dependent on the cloth cover, areal density, and packing fraction of the yarn and other parameters. Air permeability describes the characteristic of fabric to allow air to pass through. Effect of weave type, weft material and chemical processing on air permeability of fabric is as presented in figure 6.

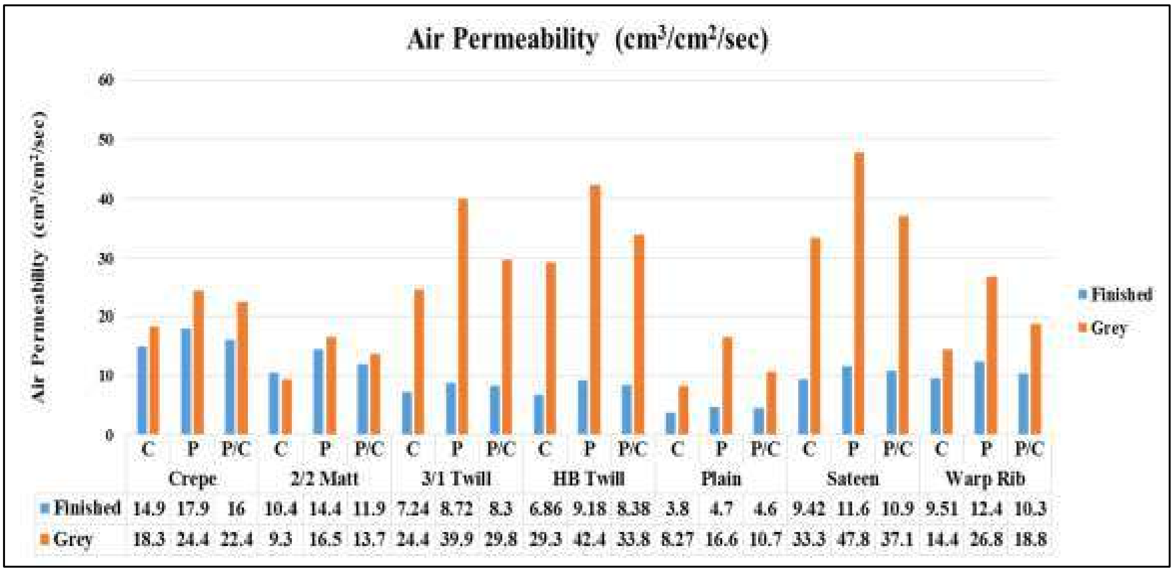

Figure 5:Air permeability of grey and finished fabrics

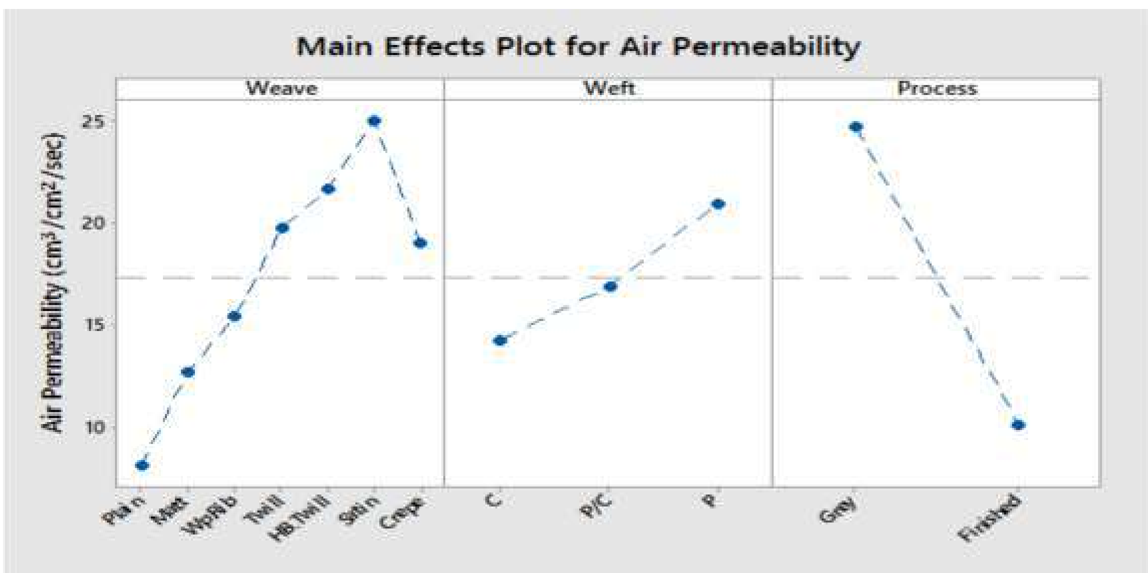

Figure 6: The effect of weave type, weft and processing on Air permeability of the fabric

It can be evidently seen from fig. 6 that the woven fabrics with plain weave structure have the lowest air permeability compared with other fabric structures. Fabric samples with satin weaves had higher air permeability followed by twill weavesand plain weaves. The lower values of air permeability of plain weave structures can be attributed to its compactness i.e. tighter structure due to the higher intersections of warp and weft yarns. It is found that the ability of a fabric to allow air to go through it freely is mainly dependent on the porosity of the fabric. When the degree of porosity is decreased, the fabric would become less permeable because little air is allowed to flow through the fabric. Shorter the floats, higher will be the interlacements and tighter will be the fabric, which results in lower fabric porosity. The difference observed between the air permeability values of weaves were due to difference in their characteristic covering properties. For equivalent weaving parameters, due to satin fabrics have longer floats and fewer intersections, it results in a looser fabric structure as compared to other structure resulting in higher air permeability. After satin weave herringbone twill weave fabrics showed higher air permeability followed by twill, crepe and plain weave derivatives viz. warp rib and matt respectively.

Statistical analysis reveals that there is a significant difference in air permeability values of the fabric woven with different weft material independent of weave and chemical processing. One of the possible reasons might be related to the fibre wetting effect of cotton fabrics. It is found that at a low differential pressure, hydrophilic fibres such as cotton would easily swell after absorption of water and the change in fabric porosity and thickness result in a decrease in air permeability. Polyester is hydrophobic in nature and it does not swell as well, hence the fabric manufactured with cotton weft has lower air permeability followed by p/c blended weft.

The finishing treatment significantly decreases the air permeability of fabrics. The difference in the moisture absorption property between the weave and weft materials is one of the reasons behind the different air permeability. Cotton fibres are hydrophilic in nature and hence absorb a greater amount of softener and other chemicals. The absorbed softener and other chemicals within fibres could block the air space between fibres or yarns, resulting in a decrease in air permeability. In case of fabric samples with polyester weft yarn, even though polyester fibres are hydrophobic in nature their fabrics show a reduction in air permeability after finishing, as the warp material is cotton.

3.4 Drapability

Drape is one of the subjective performance characteristics of the fabric that contributes to aesthetic appeal; it is a complex property involving bending and shearing deformations. Fabric drape may be defined as the extent to which a fabric will deform when it is allowed to hang under its own weight. Draping is defined as the ability of a fabric to hang in graceful folds. Draping quality is expressed as the drape coefficient which is the area covered by the shadow of the draped specimen expressed as a % of the area of the annular ring of the fabric. A lower drape coefficient value is thus indicative of better or more efficient draping behaviour. Fig. 8 exhibits the effect of fabric structure, type of weft and chemical processing on drapability of fabric.

It was observed form fig. 8 that the drape coefficient is lower in the case of satin weave fabrics indicating better drape compared to plain and twill structures. There is a significant effect of weaves on the drape coefficient of fabric. Drape coefficient of plain weave is high as compared to the rest of the weaves because short float length and high interlacement density of thread. Twill weave shows moderately high drape coefficient while satin and crepe weave show the least. Tight constructions have little mobility and do not drape as well as looser constructions. Fabrics with satin, 3/1 twill and herringbone twill weave have a maximum float and lowest index of interlacement. As these fabrics are much more flexible, they will drape down by buckling into more folds than stiff fabric like 1/1 plain [39]. The order of weaves with

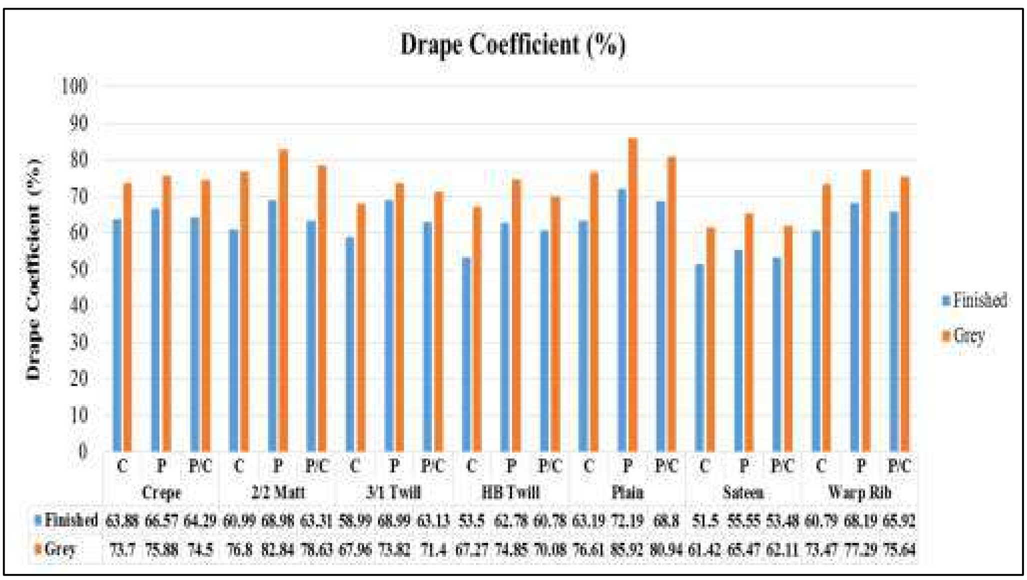

Figure 7: Drapability of grey and finished fabrics

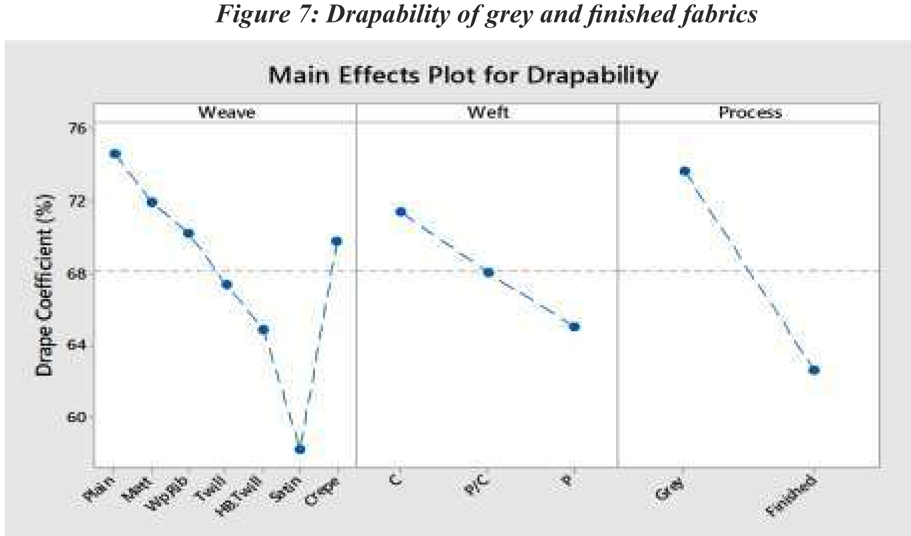

Figure 8:The effect of weave type, weft and processing on drape coefficient of fabric

increasing drape coefficient is satin, herringbone twill, 3/1 twill, crepe, warp rib, matt and plain weave.

Drape coefficient of polyester weft fabrics was found to be lower than that of cotton weft fabrics. One of the reasons behind this phenomenon is might be due to the fact that cotton gives crisper hand than that of polyester of similar linear density. Cotton yarn is stiffer than that of polyester yarn. P/C blended weft fabric show moderate drape coefficient.

Grey goods had very high drape coefficient, which implies poor drapability. This is due to the fact that an unfinished product contains many impurities like dirt, wax, etc., which entangle between the fibres and obstructs the bending property of the fabric which in turn has poor drape.

3.5 Stiffness (Bending Modulus)

Stiffness is one of the most widely used parameters to judge bending rigidity and fabric handle. Fabric stiffness and handling is an important decision factor for end-users. The degree of fabric stiffness is related to its properties such as fibre material, yarn and fabric structure. Main effects plot of weaves, weft type and finishing type is as shown in fig. 10.

It was observed that the bending modulus follows a similar trend as that of drape coefficient for all the factors. Plain fabric shows the highest index of interlacement with maximum number of intersection points and minimum float as compared to all other fabric. Hence, it results in high drape coefficient. It is stiffer fabric with longer bending length. Fabrics with warp rib, matt, crepe weave, and 3/1 twill weave show the middle range of bending modulus because these fabricshave index of interlacement lower than that of 1/1 plain fabric but more than those of 8 end satin and herringbone twill fabrics. These fabrics are less stiff as compared to 1/1 plain fabric but stiffer as compared to satin and herringbone twill fabrics.

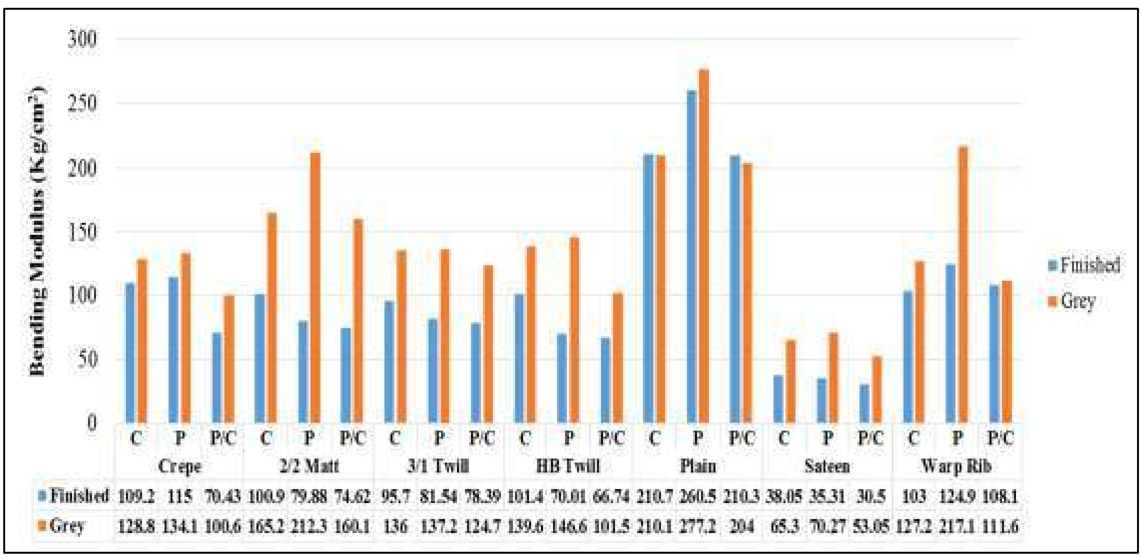

Figure 9:Bending modulus of grey and finished fabrics

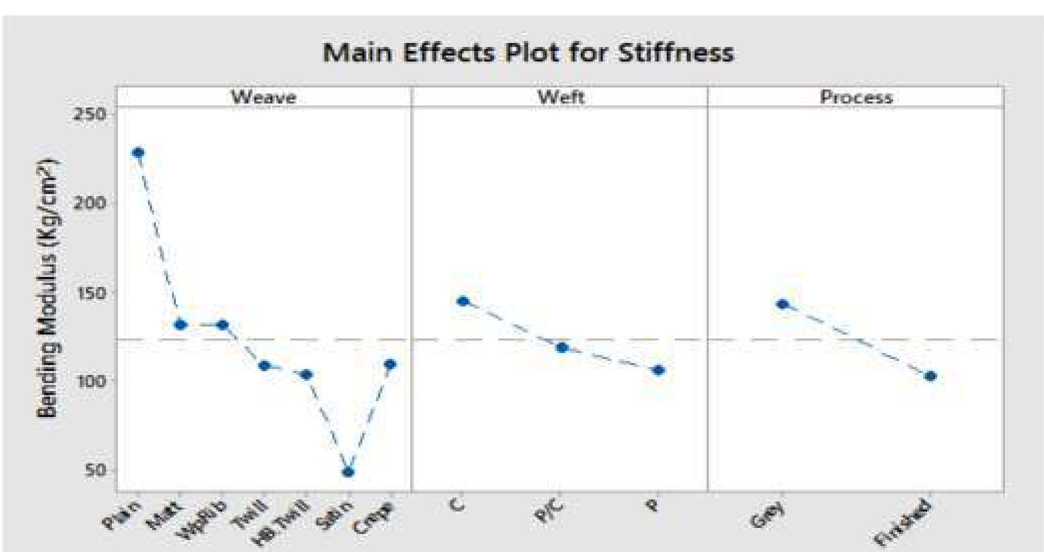

Figure 10: The effect of weave type, weft and processing on Bending modulus of fabric

Bending modulus of polyester weft fabrics was found to be lower than that of cotton weft fabrics. One of the reasons behind this phenomenon is might be due to the fact that cotton gives crisper hand than that of polyester of similar linear density. Cotton yarn is stiffer than that of polyester yarn. P/C blended weft fabric show moderate bending modulus whereas cotton weft fabric showsthe highest bending modulus.

Finishing treatment significantly reduces the bending modulus for the fabric irrespective of the weave and type of weft yarn used. This is due to the fact that grey fabric contains many impurities like dirt, wax, etc., which entangle between the fibres and obstructs the bending property of the fabric which increases the bending modulus of fabric. Also, softener used in finishing treatment softens the fabric reducing bending modulus of fabric

3.6 Wicking Properties

The ability of clothing materials to transport moisture is a critical determinant of wear comfort, especially in conditions that involve sweating. One of the methods to assess moisture transport behaviour of fabric is fabric wicking test. Fig.12 reports the effect of fabric structure, weft type and other factors on the wicking properties of fabric.

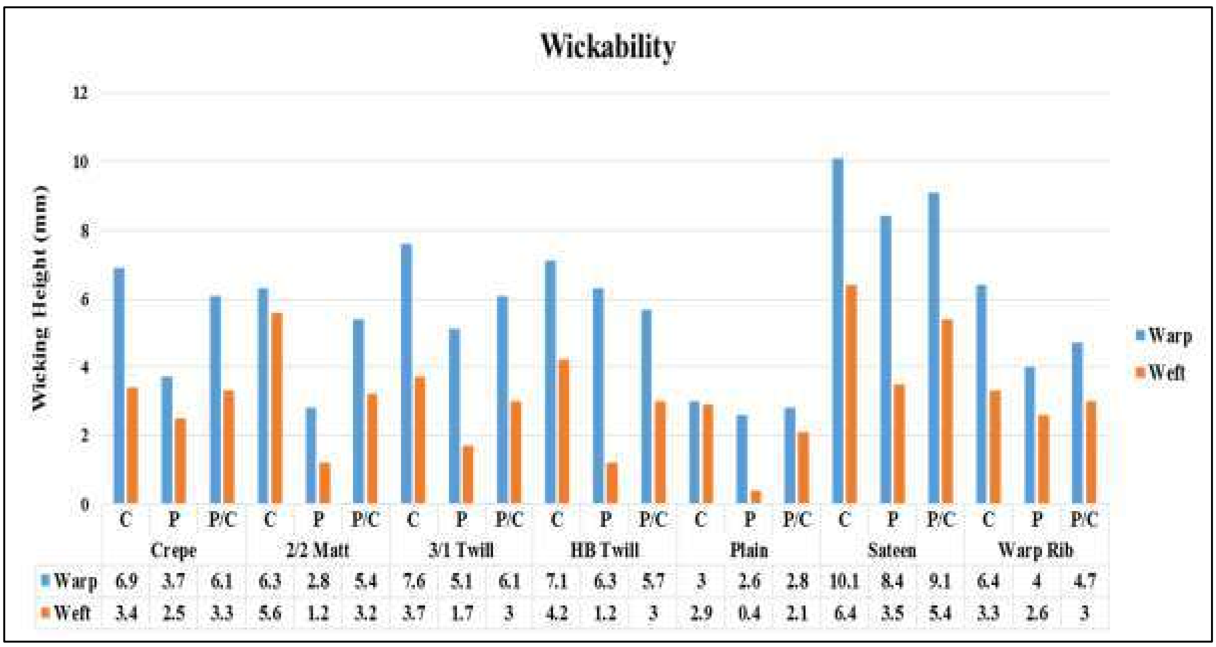

Figure 11:Wickability of grey and finished fabrics

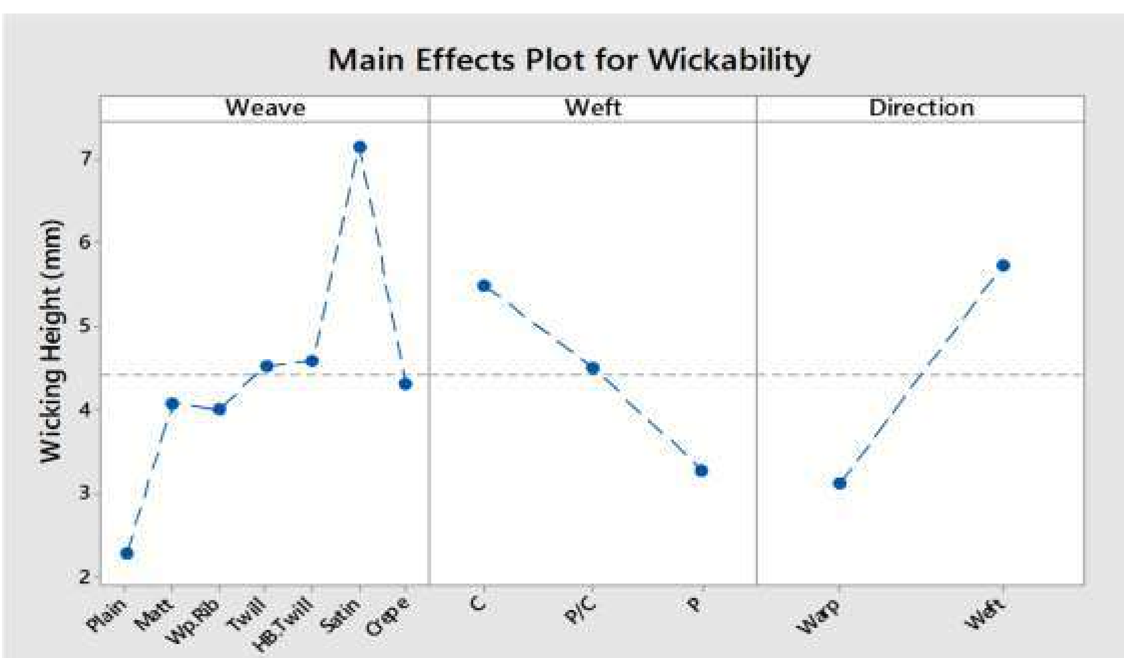

Figure 12:The effect of weave type, weft and processing on Wicking Height of fabric

From fig. 12 it can be clearly seen that there is a significant effect of weave on fabric wicking behaviour. This is because different weaves have different index of interlacement (see annexure-I), and hence different float length. More the float length more will be the water absorbed by the fabric. Plain weave has highest index of interlacement and lowest float length amongst all other weaves. Satin fabrics have highest float length followed by herringbone twill, 3/1 twill, crepe, matt and warp rib. Highest wickability was observed in case of satin and herringbone twill fabrics. Moderate wickability was observed in case of 3/1 twill and crepe weaves, whereas wickability was lowest for plain weave derivatives. Fibre content plays an important role in influencing the wickability of fabrics. This is because water is absorbed by fibres, transported through fibres, and then desorbed to the environment.In this process, the inherent absorbency of the fibres or their affinity for fibre is hydrophilic, which can absorb significant amount of moisture plays very important role.

The sample woven with cotton weft shows highest wicking height for all-time intervals compare to P/C blended and polyester fabrics. The wetting is prerequisite for wicking. The liquid does not wet the fabric cannot wick and wetting of cotton is faster than polyester fabrics. It was observed that the wicking height was higher in warp than that of the weft. There is significant difference in wickability of warp and weft direction. This is mainly because, all the fabrics were manufactured with cotton warp and different types of weft (cotton, P/C and polyester). As mentioned earlier wickability of cotton was more than that of polyester. Hence warp has more wickability than that of weft.

Grey goods have no wicking property. Even though keeping grey fabric specimen in a reservoir containing distilled water and reactive dye for 24 hours, no wicking was observed. This is because unfinished products contain many impurities like dirt, wax, etc. which prevents absorption any moisture. Whereas finished goods are free from such impurities and have good affinity towards the moisture.

4. Conclusion

The fabric sample woven with satin weave exhibited higher areal density. The fabric sample produced with polyester weft exhibiteda higher areal density of fabric irrespective of weave and chemical treatment. The plain weave sample had minimum thickness whereas satin fabric had maximum thickness.Fabric produced by polyester weft exhibited lower thickness and fabrics produced using cotton yarn have higher thickness. Finishing treatment had no significant effect on areal density and fabric thickness.

The woven fabrics with plain weave structure had lowest air permeability and fabric samples with satin weaves had higher air permeability. The finishing treatment significantly decreased the air permeability of fabrics. Fabric manufactured with cotton weft had lower air permeability. Drape coefficient was lower in the case of satin weave fabrics compared to plain and twill structures. Drape coefficient of polyester weft fabrics was lower than that of cotton weft fabrics. Plain weave fabric was stiffer than all other fabrics. Finishing treatment significantly reduced the bending modulus for the fabric irrespective of the weave and type of weft yarn used. Satin and herringbone twill fabrics had higher wickability. Wicking height was higher in warp than that of weft.

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Improving the Protection of Architecture Textiles against UVA Radiation on the Grab Tensile Strength Test Coated Polyurethane

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Abstract

Ultraviolet rays had an influence on different tissues, especially those was exposed to direct sunlight. It was demonstrated that the amount of the ultraviolet radiation (UVR) which reaches the Earth from the sun light was represented 95% of UVA. Architecture textiles were one of different types of technical textiles that were exposed to direct ultra violet radiation, as these textiles were used to shadow open places including stadiums, malls, car parking, building roofs, etc,,,. In this research two high performance fabrics were used with two different materials (Ballistic Nylon- Cordura) and yarn counts, the samples were treated with knife coating and fluorocarbon, after that polyurethane treatment were applied. The samples were exposed to UVA radiation for 80.4 hours produce 7.2 MJ/m^2, in addition to that grab tensile strength test was applied for samples before and after coating, also after exposure. Measurements results were statistically analysis using Independent-Samples T Test for all samples, the results values show that there is no significant difference between samples after treatment and UVA exposure due to the great effect of textile and treatment materials. The morphological surface of the woven fabrics was investigating using scanning electron microscope for samples before and after treatment, and after UVA exposure.

Keywords: *Architecture; Exposure; Grab Tensile Strength; Scanning Electron Microscope; UVA Radiation.*

1. Introduction

From the last decades architecture textiles (structural fabrics) become the most favorite types of fabrics used for improving the functional performance of products, these types including shading places like sports places, car parking, airports, stadium roofs and bus stops…etc. [1]. Thus, these types of fabrics considered from one of the most known textiles applications of technical textiles which manufactured with different specifications and properties, also it combined between market and industrial sectors [2, 3, 4,5]. Architecture fabrics were demanded due to its great advantages including light weight, economical designs than traditional building designs and pliability in its designs to be able to form different shapes which results in rapid construction. Despite these advantages, some drawbacks appears when using as single layer it cannot be performed some of its physical properties like sound insulation and heat trucking qualities [1, 6, 7]. Most popular architecture textiles were manufactured using synthetic woven fabrics from glass fiber material coated with polytetrafloro ethylene, or polyester fabric materials coated polvinylchoride. [1].

Coating methods were needed to provide the fabric with a smooth surface, increasing the tensile strength and durability of the membrane [8]. It were used since the eighteens century, as these types of polymers may be used either one side or both sides and also it can be applied as a several layers in order to obtain the desired properties [9, 10]. It is very important to select the polymer material used according to the required properties and product end use [9, 11, 12]. Polyurethane coating is adjustable for both scientific and industrial requirements. It is extremely used in textile industry, as it can improve its mechanical and physical properties like strength, soft or rigid, flexibility, chemical resistance and abrasion and cleaning resistance depending on its chemical structure [13]. On the other hand, Polyurethane polymer can be performed by many different ways solutions, powder according to the manufacturing technology used, as it can be used for outside applications due to its durability and against weather conditions including humidity, rain and temperature [13]. Tensile strength test considered one of the most important mechanical properties needed to be done for architecture textiles [14, 15].This work was contribute in enhancing the performance of two different materials using polyurethane coating material, against the protection of UVA radiation on the grab tensile strength test for architecture textiles.

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2. Material and Method

Two different high performance textile materials were used in manufacturing samples (Ballistic Nylon and Cordura) using different yarn counts and densities, with textile structure plain 1/1. A treatment was applied for samples using polyurethane liquid, knife coating method was used for this treatment [16] in order to increase the water proof and repellency of fabrics, the polyurethane coating was applied to the woven fabric using transfer method, the coating material was placed in the distance between the knife on the same time the polyurethane paste was utilized with the paper passed through the dryer in which the temperature was adjusted to 80 ºC [17], the manufactured samples can be presented as following, Table 2.1:

Sample (1): had yarn count 882 (Denier) and fabric density of 6*6 /inch,

Sample (2): had yarn count 504 (Denier) and fabric density of 7*7 /inch.

Table 2.1. Samples Characterization

Samples Characterization	Ballistic Nylon	Cordura
Yarn Count (Denier)	882	504
Fabrics Density (Ends × Picks/inch)	6×6	7×7
Weave Structure	Plain 1/1	
Mass per Unit Area before Treatment (g/m²)	341	288
Thickness before Treatment (mm)	0.42	0.45
Mass per Unit Area after Treatment (g/m²)	342	303
Thickness after Treatment (mm)	0.45	0.57
Mass per Unit Area before Treatment and after UVA Exposure (g/m²)	257.7	290.7
Thickness before Treatment and after UVA Exposure (mm)	0.44	0.46
Mass per Unit Area after Treatment and after UVA Exposure (g/m²)	315.3	344.33
Thickness after Treatment and after UVA Exposure (mm)	0.57	0.44

2.1. Samples Exposure

A homemade Ultraviolet exposing cabinet was used as aging toll. It consists of 10 of 20-watt ultraviolet light bulbs, aligned in parallel with each other and with the upper roof [2]. The irradiance levels at the sample level was recorded using a calibrated radiometer from Gamma Scientific, model UDT S480 connected with UV detector model 268 UVA maximum response is located at 365nm. According to the data from the General Authority for Meteorology, Egypt during the years 2010 -2013, the monthly mean ultraviolet solar radiation is 0.6 MJ/m^2 → 7.2 MJ/m^2 yearly. The samples were exposed to ultraviolet radiation at a distance of 20 cm for ٨٠ hours to provide 7.2 MJ/m^2 which is equivalent to one year exposure outdoor, noting that the samples were rotated every hour to ensure homogenous exposure. The exposing period was chosen based on the data of the average amount of sunlight falling on Egypt during the year.

Exposing Period Calculation

Total energy (Joule) = Power (Watt) × Time (second)

Given the average energy (Joule) reach the earth per year (E) = 7.2 MJ/m^2

Measured energy (Joule) in the cabinet per <u>one hour</u> (e_c) = 90000 J/m^2

Average energy (Joule) in the cabinet per 80 hours = 90000 ×80 = 7200000 J/m^2 = 7.2 MJ/m^2

2.2. Laboratory Test

All samples before, after treatment and after UVA exposure were prepared during 24 hour according to standard test method of ASTM D1776 [18]. Weight was measured using Petit Balance (Chyo) according to ASTM D3776 [19], while thickness of fabrics was measured using Teclock Corporation according to standard test method ASTM D1777 [20]. On the other hand Grab tensile strength was conducted using Galdabini universal testing machine, according to ASTM D5034 [21], with gage length 7.5 cm, rate of moving clamp (loading rate of testing machine) 300mm/min. Three replicates were applied for each sample, then the test results were calculated and the statistical analysis were presented and discussed.

2.3. Scanning Electron Microscope (SEM)

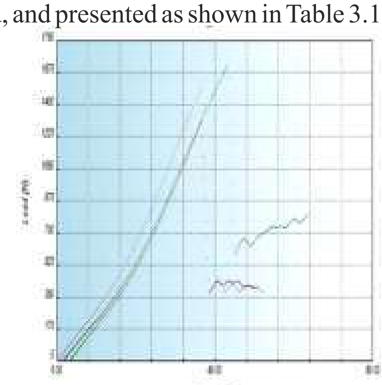
The scan morphology of samples was conducted using scanning electron probe micro analyzer (type T-scan–Czech Republic) at 5kV accelerating voltage. The ballistic nylon and cordura samples were prepared at size about 1×1 cm, staining samples were done using gold in an individual instrument. The samples were magnified in 500x to image the surface morphology of samples.

2.4. Statistical Analysis

All data were calculated and presented as mean values with their standard deviation for samples before treatment and UVA exposure, after treatment and UVA exposure. The differences between variables were measured using Independent-Samples T Test using IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows, The level of significance was at P value=0.05. All the inputs were linked to the relevant graphs by means of chart using Galdabini Universal testing machine (Tensile Strength Tester).

3. Results and Discussions

This research is devoted to measure the performance of grab tensile strength test using two different materials and yarn counts, before treatment and after exposure, after treatment and exposure. The mean and standard deviation values were calculated, and presented as shown in Table 3.1.



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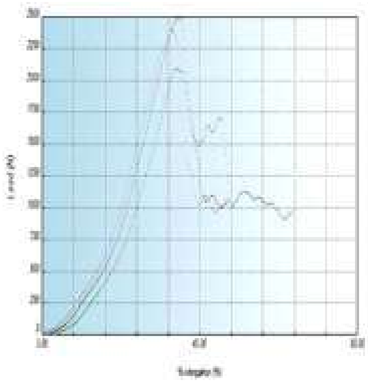
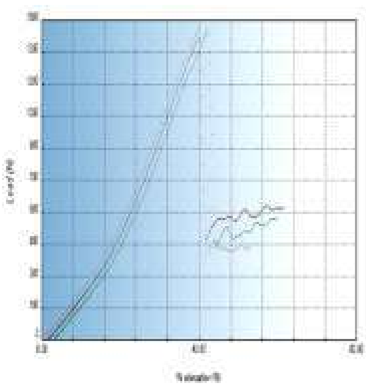


(b)

Figure 3.1. Ballistic Nylon Sample (a) before Treatment before UVA Exposure, (b) after Treatment before UVA Exposure



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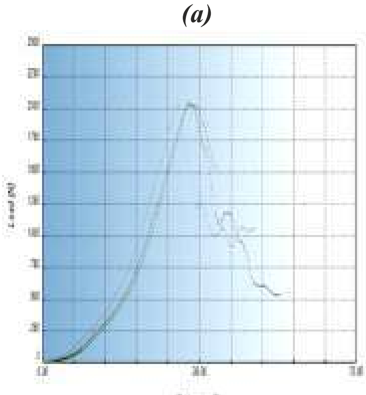
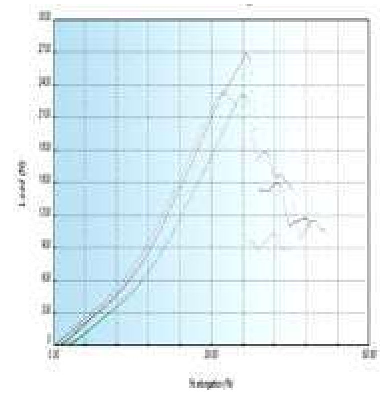


(b)

Figure 3.2. Ballistic Nylon Sample (a) before Treatment after UVA Exposure, (b) after Treatment after UVA Exposure

3.1. Samples Analysis

Figure 3.1 and Table 3.1 show that ballistic nylon before treatment and UVA exposure recorded the highest value of grab tensile strength test compared with ballistic nylon after UVA exposure, as there is no significant difference before and after UVA exposure p value (P= 0.753). from Figure 3.2 and Table 3.1, For ballistic nylon after treatment before UVA exposure recorded the highest result of grab tensile strength test compared with ballistic nylon after UVA exposure, as there is no significant difference before and after UVA exposure p value (P= 0.135).



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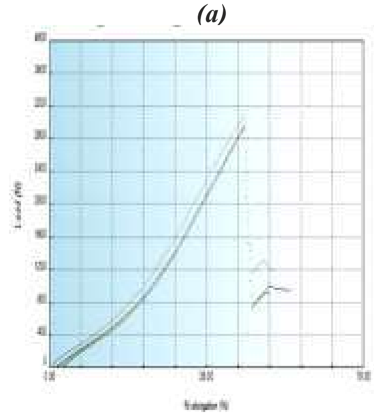
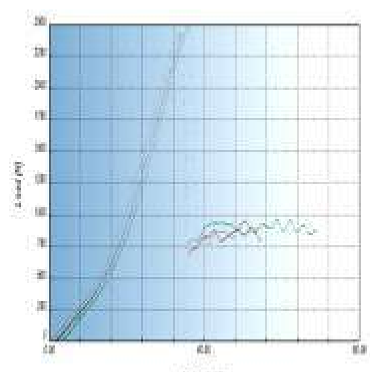


(b)

Figure 3.3. Cordura Sample (a) before Treatment before UVA Exposure, (b) after Treatment before UVA Exposure.



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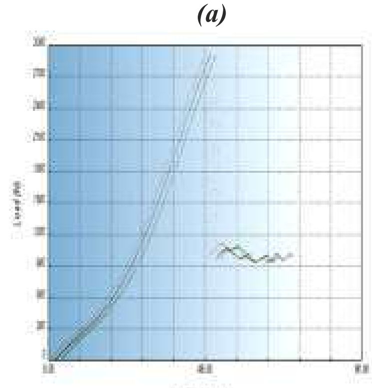


(b)

Figure 3.4. Cordura Sample (a) before Treatment after UVA Exposure, (b) after Treatment after UVA Exposure

From the statistical analysis of Figure 3.3 and Table 3.1, it was presented that cordura before treatment and UVA exposure recorded the highest value of grab tensile strength test compared with cordura after UVA exposure, as there is no significant effect before and after UVA exposure at p value (P=0.965). From Figure 3.4 and Table 3.1 for cordura after treatment, that sample before UVA exposure recorded the highest results than sample after UVA exposure at p value (P=0.169).

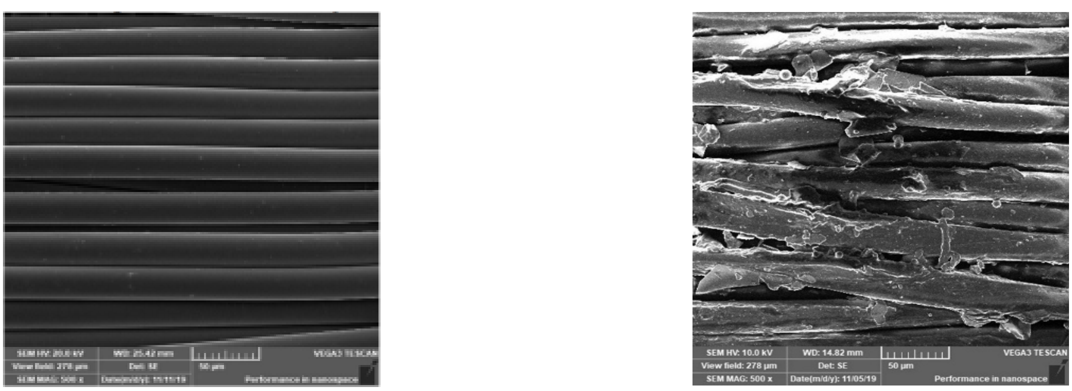
The test results indicated that exposing to UVA radiation have no effect on the samples, this can be interpreted due to the effect of high performance materials and coating treatment applied for samples with polyurethane which has good effect against UVA radiation, that not leading to lose in its chemical, mechanical and physical properties.

3.2. Scanning Electron Microscope (SEM) Evaluation

Magnification was done for all samples in 500X, Figures 3.5 and 3.7 show the SEM for ballistic nylon and cordura samples (a) before treatment and UVA exposure (b) after treatment and before UVA exposure, while Figures 3.6 and 3.8 show the SEM for the blank sample (a) before Treatment after UVA Exposure, (b) after Treatment after UVA Exposure. The resulted images show the smooth surface for blank samples for both materials while treated samples its show the penetration of coating material between fibers and also above the sample surface.

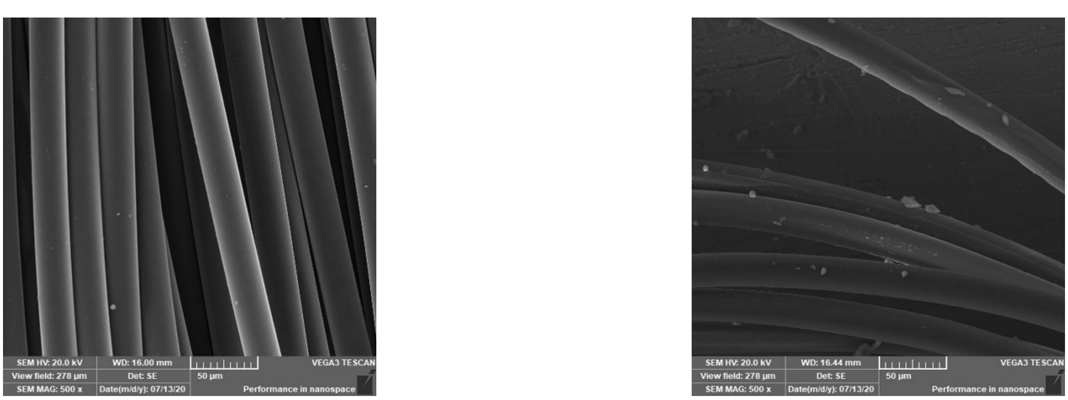
Table 3.1. Samples Statistical Analysis

Test Variables	Before UVA Exposure	After UVA Exposure	t- value	P-value
	Mean ± S.D.			
Ballistic Nylon before Treatment	1470.4 ± 149.5	1441.0 ± 23.6	0.337	0.753
Ballistic Nylon after Treatment	2327.9 ± 209.1	2034.1 ± 11.1	2.430	0.135
Cordura before Treatment	2435.7 ± 213.2	2442.0 ± 41.4	0.050	0.965
Cordura after Treatment	2989.3 ± 83.8	2889.4 ± 20.1	2.008	0.169



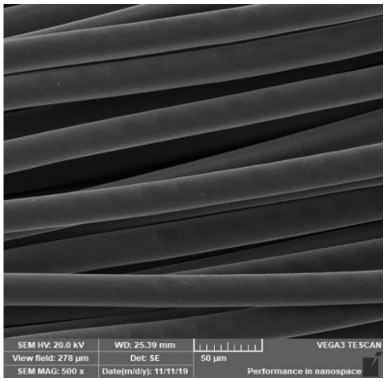
(a) (b)

Figure 3.5 : Ballistic Nylon Sample (a) before Treatment and UVA Exposure, (b) after Treatment before UVA Exposure



(a) b)

Figure 3.6 : Ballistic Nylon Sample (a) before Treatment and UVA Exposure, (b) after Treatment before UVA Exposure



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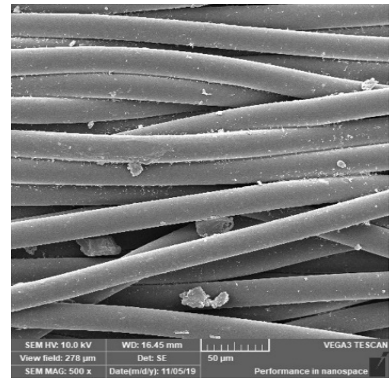
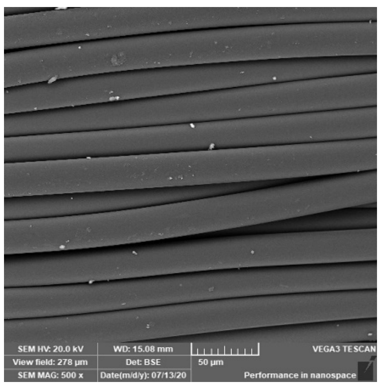
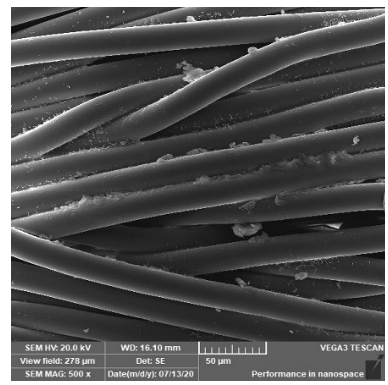


(b)

Figure 3.7 : Cordura Sample (a) before Treatment before UVA Exposure, (b) after Treatment before UVA Exposure



(a)



(b)

Figure 3.8 : Cordura Sample (a) before Treatment after UVA Exposure, (b) after Treatment after UVA Exposure

4. Conclusion

Polyurethane treatment was used to enhance the performance of two different hi-performance materials against UVA radiation, in order to be used as architecture textiles. This work was directly towards the study of analyzing the effect of UVA radiation on grab tensile test of cordura and ballistic nylon materials. The grab tensile strength test was carried out for all samples before treatment, after treatment and UVA exposure. The statistical analysis were done for all samples, which indicated that there is no significant different either before treatment or after treatment and UVA radiation. Thus, it can be interpreted due to the great effect of both textile materials and coating material used for treating samples. Finally the scanning electron microscope was conducted for samples using 500X magnifications to show the surface morphology of fabric samples.

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Retention of Efficient & Skilled Workforce Post Lockdown

Mr. Vilas V. Gharat

Mr. Vilas Gharat

Mr. Vilas Gharat, Managing Director, Gharat & Associates, have more than 50 years of experience in all composite sectors of Textile Industry. Out of which more than a decade in Operations and HR with emphasis in Business Process Consulting. Mr. Gharat have Specialization in various field of textile value chain like;

- Change Management, Business Development and Project Management
- Project Management, Business Development
- Supply Chain Management
- Resource Allocation
- Process Reengineering
- Change Management, Production and Business
- Planning Function
- Training and Mentoring CEO's

He has wide experience in:

- Business Consultant for Oswal Hammerle, for their upcoming state of art technology plant for manufacture of sophisticated Yarn Dyed Shirting Project, primarily catering to the needs of international garment manufacturers. This is a Joint Venture project of Oswal group and F.M. Hammerle (Austria)
- His previous assignment involves restructuring and transformation of a large Textile units
- He worked with various executive capacities as Executive Director - Suvin Advisors Pvt Ltd.; Senior President in S Kumar's., Technical & Commercial Advisor in J. K. Cotton Mills, Senior President in Morarjee Brembana Ltd., Birla's in Indonesia, Oswal Hammerle, Bhojsons, Nigeria etc.

Awards:

Mr. Gharat was awarded with Best General Manager Award in MSTC - National Award for energy conservation for Simplex Mills & MSTC and Best Vendor Award from Johnson & Johnson.

Mr. Gharat was awarded with FTA by The Textile Association (India) in 1999,

Mr. Vilas Gharat is a President of The Textile Association (India) - Mumbai Unit during 2017-2019 and 2019-2021.

Learning from Pandemic - 2020

- Keep your hands clean for ever
- Mask yourself for healthy living
- Stay mentally connected while observing physical distancing
- Re-orient your life style for precious life ahead
- Do not postpone your wishes & goals
- Be kind to yourself & others
- Un-tie few knots of life
- Respect human values than materialistic values
- Be self-reliant with graceful living
- Welcome humanity & human values
- Be positive critic with solution
- Do not encourage gossips
- Be kind to nature
- Be a moral supporter to needy creatures
- Be honest to yourself & exhibit your behaviour positively
- Take care of dear one's instead of worrying
- Make your life beautiful & gracefully
- Share your expertise to needy people
- Create large human banks as your wealth

2020, so called testing period for Human Beings is gradually vanishing with important learning of life. Every business except a few was in great distress but not vanished. The demand is abruptly increasing with New Systems & changed product. It's a great challenge to all of us.

Let me share the views only for Textile Industry which is having larger share of employment in India. Indian Textiles Industry made great contribution in making COVID-19 related products such as PP Kist-Masks-Anti COVID fabrics etc within span of shortest period using available resources. We can proudly say that a few of Textile Units have been exporting to developed countries.

We need to change otherwise customer will change us

In view of demand, we should try to analyse our present infrastructure with workforce available & modify-train for change. The change in Operations – Marketing & Cash Flow is very important for success. It is important to adopt all changes from Top management to workforce on shop floor.

There are many HR Tools & Systems to make such changes for example: -

- SWOT Analysis (Strength-Weakness-Opportunities & Threats)
- Auditing available machinery & assessing capability for new product.
- Re-structuring Pyramid management structure to Horizontal management.
- Restructuring Responsibilities & KRA of every individual in management.
- Restructuring SOP for all operators to achiever desire quality & quantity ON TIME.
- Design minimum but informative reporting systems for regular review.
- Creating positive & proactive Attitude in workforce by regular mentoring by experts.
- Creating incentives & awards for excellence.
- Value Human Skills & synergize their energy.
- Create Awareness among workers by displaying posters.
- Consider 2021 is New Opportunity for Progress.

COVID-19 has been Eye Opener to many progressive Organizations in case of Skilled Workforce. Initially in view of economic crises most of organizations cut packages of staff members & lay off to skilled workforce.

It is a great shock to all efficient workforces - making them to re think about their loyalty towards organization. Many of them have been under depression hence migrated to safe & proactive organizations. Those migrated to native place are now returning to stable organizations.

COVID -19 guidelines are being accepted as New Normal life & efficient workforce is being absorbed by Progressive Organizations.

2020 is coming to an end with hopes of preventive medicines; market sentiments are showing positive growth. Those who accepted challenge & changed working style are progressing vertically & horizontally. It is been observed that many new entrepreneurs are growing.

It is now realised by top managements that People Management with transparency is key for future growth. Retention of skilled workforce is very important in new normal life & hence we have started giving our services to carry out assessment of workforce from Top (CEO) to Middle Management & mentor them as per requirement for Changed management.

It believes that for survival & growth of organisation we need to change attitude of workforce. If any organization interested, we offer our service by one-to-one dialogs for improvements. We offer our services to online at present & to only Textile Industry.

Your Success -Growth is our Satisfaction.

For design & customised program as per requirement of organization is creating for small groups.

Please visit:
www.gharatandassociates.com

or contact us on
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TAI –DELHI Unit Initiated for Imparting Training to Textile Professionals


Mr. Roopak Vasistha, CEO & DG of Apparel, Made-ups & Home Furnishing Sector Skill Council signing MoU with Mr. Kamal Misra, Hon. Secretary of TAI Delhi.

The Textile Association (India) – Delhi has signed up a MoU with Apparel, Made-ups & Home Furnishing Sector Skill Council (AMHSSC), New Delhi through its CEO & DG Mr. Roopak Vasistha. Mr. Kamal Misra, Hon. Secretary of TAI Delhi Unit represented TAI Delhi on the occasion. Shri Shailesh Kaushik, an eminent Textile Professional is Knowledge Partner in this initiative of TAI Delhi Unit.

AMHSSC is the autonomous industry-led body under Ministry of Skill Development & Entrepreneurship, Govt. of India, which is responsible for creating Occupational Standards and Qualification NOS, developing competency framework, conducting Train the Trainer (ToT) and Assessor (ToA) Programs, conducting skill gap studies, and assessing and certifying trainees on the curriculum aligned to National Occupational Standards developed by them.

TAI Delhi is a reputed textile, apparel & related sectors professionals body, having convergence & synergy in the sector in which AMHSSC is operational and is keen to collaborate with the AMHSSC to conduct trainings, assessment & certification of the workforce as per National Skill Qualification Framework (NSQF).

AMHSSC has established its Centres of Excellence (COEs) in the various parts of the Country. Out of them, two such Centres at Tirupur and Delhi have started functioning. The major objectives of these COEs are;

- Training of Trainers (ToT)
- Training of Assessors (ToA)
- Management Development programs (MDPs) for Supervisory and middle management
- Entrepreneur Development program (EDP)
- Entrepreneur Cell/ Startup incubator
- Makers Space

In addition to providing quality training to the students, the most important function of COE is to provide On the Job Trainings (OJT) to the trainees.

The objective of this MOU is to establish an arrangement between AMHSSC and TAI Delhi Unit, whereby, both the parties shall together work to organize TRAINING, SKILLING, CAPACITY BUILDING and Management Development Programmes (MDPs) on Online, as well as Off line modes, provide actual training to the students.

Change in the Board of Directors of Rieter Holding AG

- **Michael Pieper is not standing for re-election**
- **Stefaan Haspeslagh will be proposed for election to the Board of Directors at the Annual General Meeting**
- **The change is related to the transfer of the shareholding of Artemis Beteiligungen I AG to Picanol Group**

Michael Pieper, a member of the Board of Directors of Rieter Holding AG since 2009, has informed Rieter that Artemis Beteiligungen I AG has sold its 11.5% block of shares to the Picanol Group (Picanol NV), Belgium, and that he thus will not stand for re-election at the Annual General Meeting on April 15, 2021.

Michael Pieper has supported and helped to significantly shape the development of Rieter for more than ten years. He joined Rieter as a major shareholder in 2008, and since then has been strongly involved in the strategic realignment of the group.

"On behalf of the Rieter Group, I extend our sincere gratitude to Michael Pieper for his extremely successful and valuable work on the Board of Directors and, above all, for his commitment as a long-term major shareholder," said Bernhard Jucker, Chairman of the Board of Directors of Rieter Holding AG.

The Board of Directors of Rieter Holding AG today announced its intention to propose Stefaan Haspeslagh for election to the Board of Directors at the Annual General Meeting on April 15, 2021.

Stefaan Haspeslagh (born 1958) holds a Master's degree in Applied Economics from the University of Antwerp, Belgium. He has been Chairman of the Board of Directors and Chief Financial Officer of the Picanol Group (Picanol NV), Belgium, since 2010. In addition, Stefaan Haspeslagh has also been Chairman of the Board of Directors, Chief Operating Officer and Chief Financial Officer of the Tessenderlo Group NV, Belgium, since 2014. As a director of Cellpack NV, Belgium, he has been in office since 2001.

"Rieter welcomes the new major shareholder, Picanol NV. Luc Tack, majority shareholder and CEO of Picanol, has been a member of the Board of Directors of Rieter for four years. Stefaan Haspeslagh is characterized by broad, international management experience in the textile sector and is very well connected in the industry", stated Bernhard Jucker, Chairman of the Board of Directors.

All other current members of the Board of Directors will stand for re-election at the Annual General Meeting.

Clear Choice - Security, Prevention and Flexibility

New Uster Quantum 4.0 yarn clearer offers spinners the best of both worlds

Which yarn clearing technology should spinners choose? Now there's only one answer, as Uster launches the new Quantum 4.0 clearer generations. This world-beating innovation combines both capacitive and optical sensors in one – delivering comprehensive security, prevention and flexibility.

The Smart Duo system offers the best of both worlds for intelligent yarn quality control and optimized profitability. It means mills can now focus on meeting the fast-moving market challenges, instead of pondering technical options.

Security and reliability: the basis of yarn quality

Quantum 4.0 is like a dream come true for the industry. For years, spinners have wished for a way to bring the best of different technologies together, for secure quality and maximum flexibility.

Spinners can now access full security in quality control, ensuring the best clearing mode is applied. The Quantum 4.0 enables this through a simple Capacitive/Optical switch. This allows greater flexibility in the types of yarn which can be produced, while also dealing with factors such as humidity variations.

Intelligent sensors in tandem

The capacitive and optical sensors work intelligently in tandem through an innovation known as Cross Clearing. This locates and eliminates hidden defects by means of a double check, in which the main sensor's signal is supported by the assistance sensor. This deals with issues such as unnoticed fluff events, which might otherwise cause breaks downstream.

Today's market trends show strong demand for compact yarns. Here, spinners can trust Quantum 4.0 to tap this potential and deal with any quality issues. The density feature, for example, protects mills from substandard cops caused by ring spinning malfunctions such as blocked compacting zones, or twist problems. The Smart Duo has the advantage of monitoring yarn density continuously and after every splice. "No matter where density variations originate, be it compacting, different twist levels due to slip spindles or otherwise, Uster Quantum 4.0 takes care of it – and this is a real technical innovation," says Katrin Hofer, Product Manager at Uster Technologies.

No more material mix-ups

A further valuable innovation with Quantum 4.0 is the Blend Mix-up option, which now enables mills to identify mix-ups of different types of raw materials. This long-awaited market request detects any wrong raw material in greige and white yarns, combating the infamous, but serious, barré effect in fabrics. Cop mix-ups can happen in mills, since differences are hardly visible to the human eye. But Quantum 4.0 stops the problem before it becomes an issue, thanks to significantly improved hardware and software – all underpinned by the Smart Duo.

The higher processing power of the new sensors brings additional benefits such as the enhanced Continuous Core Yarn option, which detects both missing and off-center core continuously.

Innovations in Quantum 4.0 also focus on contamination, with deeper analysis of polypropylene and foreign matter. A new PP classification gives users the overview of polypropylene content, while the Advanced FD classification now shows extra classes below the 5% lines. Both these features add to the value of the contamination function, together with Total Contamination Control (TCC).

Quantum 4.0 gives spinners the ultimate confidence through the intelligent interaction of capacitive and optical sensor technology. It achieves 'one of a kind' security levels in basic clearing, while also cutting only what's necessary.

Prevention pays off

As well as identifying defects at winding, preventing defects at source is also in focus with the clearer's new Expert System. The new Quantum Expert is now included in the product offering. Thanks to many added intelligent analytical features, the Uster Quantum Expert enhances process control and prevention of defects, through Total Contamination Control, Ring Spinning Optimization and the RSO 3D Value Module.

Latest innovations in the new clearer protect spinners from claims and waste – but enabling business success is the real purpose of Quantum 4.0. Latest clearing technologies work with Uster's unique data analysis to enable flexible data-based decisions using Application Intelligence. "Failure prevention is the key to success and tackling issues at source is the way to do it. Uster Quantum 4.0 plays an important role in this, offering options to strengthen it," says Hofer.

Secure and user-friendly

The secret of true innovation is how well it is designed through to the point of user interaction. No matter how much data – in terms of quantity and different parameters – is collected for analysis, Uster Quantum Expert manages the complexity, while staying as intuitive as ever.

With Quantum 4.0, a new central Smart-Limit button enhances flexibility, since operators can adjust all available smart limits with a single tap, based on the unique Yarn Body concept. Each individual limit can be simply fine-tuned as preferred.

Users enjoy the established Quantum workflows and embrace the new customer-centered user interface with a 16:9 touchscreen on the 7th generation control units`.

Nothing gets in the way of success with this prevention strategy. Uster recognizes that today's challenges are tough, can be overcome with prevention, security and flexibility on your side – and Quantum 4.0 on your winding machine.

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COLORJET Colorjet & Konica Minolta : A Strategic Global Partnership

KONICA MINOLTA

Two giants in their own spheres - Konica Minolta, Japanese multinational and world leader in optical digital print, and Colorjet, the largest manufacturer of digital inkjet printers in India have formed a strategic global alliance. As part of this renewal of decades old partnership, Konica Minolta would promote ColorJet digital textile printers through their global sales network.

This marks a new milestone in the decades old strategic partnership of Colorjet & Konica Minolta.

ColorJet is the largest and leading digital printer manufacturer in India, well-known for delivering smart solutions of digital large format printers that enable users to enhance their business proposition and maximize their ROI.

For years, Colorjet Digital Textile Printers, for example, VastraJet and Metro have been designed around Konica Minolta's industry-leading cutting-edge reliable print heads - a testament to the long-standing and established business relationship between the two companies.

This strategic partnership between Konica Minolta and Colorjet would make it possible to offer comprehensive solutions to the digital textile print industry all over the world, using the combined technological and commercial channel leadership of both companies.

There are no other large format printer manufacturers other than Colorjet with a range of print solutions, which seamlessly integrate global best-in-class technologies. Colorjet has been delivering enhanced business values to the most demanding of customers since 25 years with more than 4,500 Colorjet printer installations.

“The philosophy behind Colorjet products has been 'Smart Indian Engineering' for sustained long-term profit and this is what diverse customers want,” MS Dadu, Chairman and Managing Director of Colorjet India, said.

The new strategic arrangement between Colorjet and Konica Minolta aims to result in a gain of 15-17% market share in their target countries. This would be made possible with the increased product range that would appeal to a much wider range of textile and apparel industry entrepreneurs and because an optimized value would be delivered in terms of product and service.

Initially, the strategic sales collaboration will start in China, Pakistan and subsequently the partnership will extend to other countries.

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KARL MAYER High-tech Solutions for the Textile Industry in Asia

KARL MAYER will be presenting innovations focusing on digitalisation at ITMA ASIA + CITME, in Hall 4, Stand A 32 at the NECC, 12-16 June 2021

KARL MAYER will once again be presenting itself as a pioneer of digitalisation at ITMA ASIA + CITME, located in Hall 4, Stand A 32. The innovative market leader offers innovative digital solutions for all its machine segments, enabling customers to benefit from unprecedented flexibility, efficiency and, above all, independence.

These digital trendsetting offers will be the focus for each of the three powerful brands in the expanding Group: KARL MAYER, KM.ON and – most recently – STOLL. For the first time in Asia, KARL MAYER will be exhibiting machines with the highest market relevance for both warp knitting and flat knitting. "The upcoming ITMA ASIA+CITME is a very special trade show for us in two respects. After a long pause in face to face communicaton, we are looking forward to exchanging ideas with our customers in person again in China, our most important market. In addition, this is our first trade fair appearance together with STOLL. Visitors from both the warp knitting and flat knitting sectors, as well as from the warp preparation and technical textiles sectors, will be able to find out all about the opportunities for new business, stronger market positions and optimized production processes," said Arno Gärtner, CEO of the KARL MAYER Group.

On show at the exhibition stand will be an HKS, two machines from the ADF family and a new flat knitting machine for the volume market. All models offer unique possibilities thanks to digital features that keep the customer one step ahead when it comes to modern production processes. For visitors from the field of weaving, KARL MAYER will be exhibiting the ISODIRECT beam warping machine with an excellent price-performance ratio.

KARL MAYER founded KM.ON to develop pioneering digital products. The company's own software start-up made its first major market appearance at ITMA ASIA + CTME in 2018, and this time round, it will showcase new and enhanced digital solutions that are highly effective in helping customers do business.

The possibilities afforded by digitalisation are also a pillar of Care Solutions, KARL MAYER's new concept for an even more comprehensive, focused and solution-oriented after-sales service. The SPARE PARTS WEBSHOP is part of this. The procurement tool is already well established on the market and can now also be used to procure electronic lapping data. The SwapKnit 36 and SwapKnit 36 Flat have been developed for this purpose and will be presented at ITMA ASIA + CITME.

In addition, an exclusive textile and application demonstration on the KARL MAYER stand will open up new market opportunities for visitors. Highlights include high-performance geotextiles and construction textiles for manufacturers of technical textiles, on-trend warp knitted fabrics for brands and fabric producers from the sportswear, underwear and fashion sectors, and denim fabrics through which KARL MAYER demonstrates its strength in indigo dyeing.

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ITMA 2023

ITMA 2023 Stand Space Application opens

Product Index expanded to 20 Chapters with inclusion of Composite Technology

Stand space application for ITMA 2023 will open on 3 March. The world's largest textile and garment technology exhibition, ITMA will be held at Fiera Milano Rho, Milan, from 8 to 14 June 2023.

Following its successful showcase in Barcelona in 2019, interest in the upcoming exhibition remains high despite the ongoing Covid-19 pandemic. According to its show owner CEMATEX, and organiser ITMA Services, many enquiries have been received from interested participants since last year.

Mr. Charles Beauduin, Chairman of ITMA Services, explained: “The pandemic has changed the world in many unprecedented ways. We are now moving into a new world where the digital space has become more commonplace. At the same time, it has underscored the importance of face-to-face meetings, which all of us will appreciate more than ever once it becomes possible again.

“Many textile technology builders are using these couple of years to consolidate their business, and to advance their research and development efforts to stay competitive. As such, by the time ITMA 2023 is held, they will be ready to showcase their latest innovations in Milan.”

Mr. Ernesto Maurer, President of CEMATEX, added: “In the meantime, we are also looking at various ways to help textile and garment industry players maximise their participation at ITMA 2023. Exhibitors will be able to explore additional avenues to promote their latest machinery and solutions through our new digital platform, which will help to connect exhibitors and visitors before their face-to-face meetings at ITMA 2023, and after the exhibition. We have also expanded and refined our product index to reflect opportunities in the marketplace.”

Expanded product index

ITMA 2023 will feature 20 chapters. A new chapter on machinery for textile reinforcement structures for composites, auxiliary machinery and accessories, has been created to address the needs of buyers in this growing sector.

Mr. Beauduin explained, “ITMA 2023 features solutions for an entire textile and garment manufacturing value chain. The composite industry is bursting with opportunities. While composite solutions have been showcased at past ITMA editions, we are now making it easier for buyers to source these technologies by clustering them in one sector.”

Among the first to applaud this move is Peter D. Dornier, Chairman of the Board of Management, said: “It's great to learn that technology for textile composites which have been showcased at ITMA for many years, has now been established as a separate product chapter to give the sector more visibility. At the last exhibition in Barcelona, we successfully launched our P2 rapier weaving machine. The machine was very well received by visitors from various industry sectors, ranging from clothing, home and technical textiles, to composite material manufacturing.”

Other past ITMA exhibitors excited about the new sector include Luke Vardy, Managing Director of Cygnet

Texkimp. He enthused, "As a regular ITMA exhibitor and established manufacturer of fibre processing machinery for the technical fibre markets, we feel that the dedicated composites chapter will present us with more focused opportunities to showcase our solutions to the existing wide array of visitors from various industries such as aerospace, automotive, defence and medical."

Chapter 11 will feature machinery for textile reinforcement structures for composites, as well as auxiliary machinery and accessories. Included in the chapter are:

- Machines for the production and treatment of special fibres, such as carbon, glass and aramid fibres
- Filament winding machines
- Fibre spreading machines
- Tape laying machines, fibre placement lines
- Coating and impregnation machines for prepreg production
- Other machines for the production of reinforcement structures
- Special testing equipment for textile reinforcement structures
- Auxiliary machinery and accessories for machines for textile reinforcement structures

Further reflecting current industry demands and needs, the ITMA 2023 product index has been updated to feature equipment for textile recycling, such as textile sorting systems and chemical recycling technology.

The chapter on software and automation for design, data monitoring, processing and integrated production has been expanded to include digital platforms for textile and clothing production, procurement of textile materials and B2C platforms for retail. There is also a bigger range of solutions for automation of production processes, and tracking and tracing of products.

Themed Transforming the World of Textiles, ITMA 2023 is expected to draw strong response. The recent ITMA 2023 virtual launch received enthusiastic response.

The event recording can be viewed on itma.com. More details on stand space application can also be found on the website.

The last ITMA exhibition, held in Barcelona in 2019, had featured exhibits from the entire textile and garment making value-chain, including raw materials and fabrics. It drew a record-breaking participation of 1,717 exhibitors from 45 countries and visitorship of over 105,000 from 136 countries.

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LANXESS signs contract with Emerald Kalama Chemical

- **Acquisition with sales of USD 425 million and EBITDA of USD 90 million to strengthen Consumer Protection segment**
- **Enterprise value of USD 1.075 billion**
- **High-margin new application fields in food industry and animal health**
- **Rapid integration expected**

LANXESS headquarters in Cologne

Specialty Chemicals Company LANXESS is accelerating its growth course and signed a binding agreement to acquire 100 percent shares in Emerald Kalama Chemical on February 14, 2021. The US-based company is a globally leading manufacturer of specialty chemicals, especially for the consumer segment, and is majority-owned by affiliates of the US private equity firm American Securities LLC.

The enterprise value of Emerald Kalama Chemical amounts to USD 1.075 billion. After deducting debt-like items, the purchase price is around USD 1.04 billion (EUR 867 million*), which LANXESS will finance from existing liquidity. The transaction is expected to be completed in the second half of 2021. It is still subject to approval by the relevant authorities.

In 2020, Emerald Kalama Chemical achieved sales of around USD 425 million and EBITDA pre exceptional of approximately USD 90 million.

Within three years following the completion of the transaction, LANXESS expects an additional annual EBITDA contribution of around USD 30 million (EUR 25 million*) from synergy effects. The acquisition will already be earnings per share accretive in the first fiscal year after its completion. (*Based on exchange rate of EUR/USD = 1.20).

"We are gaining further momentum on our growth course. The businesses of Emerald Kalama Chemical are an ideal fit for us. We will further strengthen our Consumer Protection segment and open up new application areas with strong margins, for example in the food industry and animal health sector. In addition, we will also enlarge our presence in our growth region of North America. All this will make us even more profitable and stable," said Matthias Zachert, Chairman of the Board of Management of LANXESS AG. Emerald Kalama Chemical employs approximately 500 employees worldwide and runs production sites in Kalama, Washington (USA), Rotterdam (Netherlands) and Widnes (Great Britain). Emerald Kalama Chemical generates around 45 percent of its turnover in North America. "Emerald Kalama Chemical has a very efficient setup, bundling all its production activities at only three sites. That is why we expect to integrate the new business very quickly," said Zachert.

Targeted portfolio expansion in the Consumer Protection segment

Emerald Kalama Chemical generates about 75 percent of its turnover with specialties in the consumer segment. These include preservatives for food, household and cosmetic applications, flavors and fragrances as well as products for animal nutrition. The remaining 25 percent of sales come from the specialty chemicals business for industrial applications, including the plastics and adhesives industries. With the acquisition, LANXESS is pursuing a targeted expansion of its portfolio: The Company has a strong position in the global business with antimicrobial active ingredients and preservatives, including for consumer protection products and animal hygiene. Examples are disinfectants effective against the Corona virus or the African swine fever.

LANXESS is a leading specialty chemicals company with sales of EUR 6.8 billion in 2019. The company currently has about 14,400 employees in 33 countries. The core business of LANXESS is the development, manufacturing and marketing of chemical intermediates, additives, specialty chemicals and plastics. LANXESS is listed in the leading sustainability indices Dow Jones Sustainability Index (DJSI World and Europe) and FTSE4Good.

For further information, visit at:
http://webmagazine.lanxess.com

KARL MAYER

Next Generation Digitalisation

The new HKS 3-M ON with a completely new patterning concept and even greater output

At ITMA 2019, we successfully presented the HKS 3-M ON as one of the first machines linked to the digital world of KARL MAYER. The innovative model works with data loaded directly from KM.ON's secure cloud rather than pattern disks. It is based on the new ON pattern drive and networking the machines via k.ey. The HKS 3-M ON thus offers the simple, fast pattern change of EL gears, while doing so at the speed of machines with N pattern drives. At the WTiN virtual trade show, the manufacturer launched the next step for this development in a wider working width. The new HKS 3-M ON 280" is even faster than its predecessor – up to 15 % – and with a completely new multi-model concept, it offers maximum flexibility in patterning. With different models, customers can quickly and easily adapt the machine's patterning possibilities to current market and budget requirements.

Abb1 Key Cut out-shadow

Abb2 Knitting Elements

Three models, various patterning possibilities

In future, KARL MAYER will have two business models for creating new articles on the HKS 3-M ON, offering three different interchangeable options and thus maximum flexibility The first two variants – SwapKnit 36 and SwapKnit 36 Flat – are suitable for designs with repeats of to 36 stitch courses. Anyone who selects these machines can purchase lapping patterns from KARL MAYER'S WEBSHOP SPARE PARTS in just a few clicks, load them onto their machine and create new or old, tried-and-tested products. Variant three has been developed for pattern repeats over 36 stitch courses. It uses web-based software k.innovation – CORE by KM.ON, which includes a lapping editor. The intelligent software solution derives the chain link notation for a new design and then creates the pattern files that are processed by the HKS 3-M ON. A technical prerequisite for using all three variants is that the machine must be connected to the KM.ON cloud via k.ey. To offer attractive economic opportunities, various business models are available. While customers can buy single lappings or a whole catalogue of lapping patterns for SwapKnit, a licence can be obtained for k.innovation –CORE. The licence regulates the period of use. This means individual variants can be chosen completely flexibly. A change by article is possible, as is using one of the three options in the long term. This makes the HKS 3-M ON a hybrid all-rounder that combines the patterning possibilities of typical N and EL pattern drives in a single model.

Fast and flexible pattern changes thanks to ON Drive

It only takes a few simple steps to purchase the lapping and then change the pattern on the HKS 3-M ON. KM.ON's cloud plays a crucial role in this process. After placing the order via the WEBSHOP SPARE PARTS, the lapping data is released by the storage platform and displayed on the machine user interface (BO) of the machine, which is networked with the cloud via k.ey. The lappings for the intended product are put together using the easy-to-use human-machine interface. What's more, further product data can be stored in the cloud via the BO, and the product can be loaded. Once saved, the articles with the stored data are available for retrieval at the machine at any time.

Enhanced performance thanks to extended widths

The HKS 3-M ON also offers greater flexibility than ever before with a larger working width than its predecessor. An increase of up to 20" is possible. Now with a maximum of 300", wider items can be produced or several narrow fabric lines can be produced beside one another with a higher variance in number and width. In addition, the expanded working width and a higher speed result in a significant increase in productivity.

Simplified operation, shorter downtimes

In addition to higher performance, the latest generation of HKS 3-M ON in 280" is easier to operate compared with previous models. The newcomer stands out by offering improved handling, particularly when changing warp beams. A moveable ladder makes it easy to access the couplings and a side work platform provides additional support access. In addition, it is considerably easier to remove the guide bars thanks to a well thought-out solution. These changes will also be rolled out for the HKS 3-M ON across further working widths and other machine types.

The fastest way to the required lappings

SwapKnit is a new, fast and flexible way of purchasing lappings for the HKS 3-M ON and loading them directly onto the machine. It is therefore possible to change products in no time at all. To meet customers' individual needs, two variants are available: Swap- Knit 36 for purchasing individual electronic lappings and SwapKnit 36 Flat for accessing KARL MAYER's lapping database. Both options can be obtained via KARL MAYER'S WEBSHOP SPARE PARTS.

SwapKnit 36 for per-lapping purchases

For the SwapKnit 36, individual lappings are ordered for each ground guide bar – similar to the now-familiar principle of the pattern disk. The purchased lappings remain available to the customer in the cloud and can be used successively on several machines. Procurement is therefore possible in just a few clicks. The WEBSHOP SPARE PARTS is easy to navigate so customers arrive at their goal quickly. To get started, the machine number is required. Then enter the repeat length, position of the guide bars and the required lappings before placing the order. No delivery time, no packaging, transport or customs clearance costs and indeed no installation – this is what the future looks like!

SwapKnit 36 Flat for flat-rate purchases

SwapKnit 36 Flat offers additional flexibility with a flat rate. For a fixed rate, a selection of lappings are provided, which can be used on a machine selected for this variant over a certain period of time. The possible period of use is 1 month, 3 months or 12 months. SwapKnit 36 Flat can also be purchased easily and quickly via the WEBSHOP SPARE PARTS, thereby offering the same advantages as SwapKnit 36.

k.innovation – CORE for longer patterns and easy collaboration opportunities

Using the k.innovation – CORE software solution, longer patterns can be created flexibly. The customer can simply use their log-in details to access the k.innovation – CORE from any web browser on an internet- enabled device and immediately start creating patterns. They then select the machine, enter the lappings for the individual ground guide bars and subsequently create a pattern file in just a few clicks. With a further click, this pattern file is sent to the KM.ON cloud and then securely made available to the ON machine. All that remains is to select the file on the machine's user interface and production can get underway. What's more, k.innovation – CORE helps to optimise the development process by opening up collaboration opportunities. External, authorised parties can be added to individual "projects" to view, collaborate on and communicate about the designs. It is also possible to share files via the software and therefore cuts out the need to send documents reciprocally, which can often be a cumbersome process. As with SwapKnit 36 Flat, a licence for k.innovation – CORE can be purchased to cover a certain period of time: either 3 or 12 months. During this period, the customer can use the software flexibly to create patterns.

Short time-to-market, high efficiency

The lappings ordered using both SwapKnit variants are available immediately, as are the pattern files created via k.innovation – CORE. They can be used for fast lapping changes, without posing any modification risks at the machine and with only minimal downtime. Customers can respond to market requirements within the shortest possible time and use their machines with maximum efficiency. Using the acquired virtual pattern rack or a specially created collection of pattern files, customers can also save money by not having to store pattern disks.

Stylish warmers

4D-KNIT fabrics opened up new design possibilities in the clothing sector

Front

Back

KARL MAYER's new 4D-KNIT generation of warp knitted fabrics opens up previously unknown possibilities in design and product development. The fabrics' striking features are distinctive relief-like surface designs; the machine is based on using the double bar raschel technique. An RDPJ 6/2 EL with a clever guide bar arrangement and technical configuration is used to produce these eye-catching articles. The double needle bar raschel machine does not produce a classic spacer textile with monofilaments for spacing, but the space between the cover surfaces is filled with a bulked yarn. In addition, differently shrinking yarns are processed in intelligent combinations on the front and rear side of the warp knitted textiles and different lapping techniques are used.

During the finishing process, this leads to high-low effects with differentiated markedness. Voluminous fabrics with small and flat reliefs or deep and bulky shapes with various motifs are created. Strict geometric arrangements with high-low effects are just as possible as expansive plastic wavy arrangements, sparkling fruit looks or complex imaginative designs with different height profiles.

Even hole patterns can be seamlessly and freely placed incorporated into the textiles. Functional clothing and shoes in particular provide breathability and a stylish look with the mesh parts. Additional colour and shape effects can be achieved when using suitable yarns.

Especially designers and product developers in the clothing sector can enter completely new territory thanks to these articles with their futuristic looks and voluminous structure. The athleisure jacket on this page shows the initial opportunities. The stylish outfit combines different pattern parts seamlessly in one piece on the rear side, is comfortable to wear and keeps you cuddly warm as the seasons change. The excellent insulating effect is achieved by filling the plastic structure with air and yarn material. The filament yarns are enclosed by the dense fabric on the surfaces. This should result in few micro-particles being released during washing.

Initial comparative tests with nonwovens at the FH Niederrhein have already delivered promising results. The investigations carried out to date on the first machine wash are currently being complemented by follow-up washings. Kettenwirk-Praxis will report on the results soon. A 4D Knit pattern can be seen in the Pattern part of this issue.

For more details, please contact:

Presseinformation / Press release

Postanschrift / post address:
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Industriestraße 1, 63179 Obertshausen

Mediakontakt / media contact:

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The Textile Association (India) – Central Office

(Registered under the Society's Registration Act XXI of 1860 and under Bombay Public Trust Act XXIX of 1950)
702, Santosh Apartment, 7th floor, 72-A Dr. M. B. Raut Road, Dadar (West), Shivaji Park, Mumbai – 400 028
Tel: 022-24461145, E-mail: taicnt@gmail.com
(Subject to Mumbai Jurisdiction)

RESULTS FOR ATA PART – I, PASSED/ATAHE CANDIDATES - DECEMBER, 2020

Centre / Result	PASS	ATAHE
Ahmedabad	2020/01, 2020/02, 2020/03, 2020/04	Nil
Bhilwara	Nil	2020/10
Ichalkaranji	2020/20, 2020/21	Nil

	Registered	Appeared	Passed	ATAHE	PASS %
Total	07	07	06	01	85

RESULTS FOR ATA PART – II - DECEMBER, 2020

Centre / Result	PASS	ATAHE
Ahmedabad	2020/506, 2020/507, 2020/508, 2020/509, 2020/510, 2020/511, 2020/512, 2020/513, 2020/514	2020/501, 2020/502, 2020/503, 2020/504, 2020/505
Bhilwara	2020/521	2020/520
Ichalkaranji	2020/531, 2020/533	2020/530, 2020/532

	Registered	Appeared	Passed	ATAHE	Passed %
Total	20	20	12	08	60

Result withheld of Roll Nos. 2020/507, 2020/520, 2020/530, 2020/531, 2020/532, 2020/533 for non Submission of Industrial Report of Ahmedabad, Bhilwara & Ichalkaranji Centre.

RESULTS OF ATA PART – III PASSED CANDIDATES DECEMBER, 2020

Centre	Yarn Manufacture	Fabric Manufacture	Textile Wet Processing	Knitting & Garment Manufacture
Ahmedabad	2020/601, 2020/602, 2020/604, 2020/607	Nil	2020/801	2020/902
Bhilwara	Nil	Nil	Nil	Nil
Ichalkaranji	Nil	Nil	Nil	Nil

Result withheld of Roll Nos. 2020/602, 2020/603, 2020/604, 2020/901, 2020/902, 2020/903, 2020/904 for non submission of Industrial report of Ahmedabad & Ichalkaranji Centre.

Candidate	Yarn Manufacture	Fabric Manufacture	Textile Wet Processing	Knitt. & Garm. Mfg.	Total
Registered	08	01	01	04	14
Appeared	08	01	01	04	14
Passed	04	Nil	01	01	06

Pass 43 %

Sd/-
Dr. G. S. Nadiger
Chairman, PAC

Sd/-
Haresh B. Parekh
Hon. Gen. Secretary

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RESULTS FOR GMTA SECTION A/B/C/ PASSED CANDIDATES DECEMBER, 2020

Centre	Section A	Section B	Section C
Ahmedabad	2020/AHA/01, 2020/AHA/02 2020/AHA/03	2020/AHB/01, 2020/AHB/02 2020/AHB/03	Nil
Ichalkaranji	Nil	2020/ICB/10, 2020/ICB/11 2020/ICB/12	Nil

Candidates	Section - A	Section -B	Section -C	TOTAL
Registered	03	06	04	13
Appeared	03	06	04	13
Passed	03	06	Nil	09

Pass 69%

RESULTS FOR GMTA SECTION D & E - PASSED CANDIDATES DECEMBER, 2020

Centre	Section-D				Section- E
	Yarn Manufacture	Fabric Manufacture	Text. Wet Processing	Apparel Manufacture	
Ahmedabad	Nil	Nil	Nil	Nil	2020/AHE/01
Ichalkaranji	Nil	Nil	Nil	Nil	Nil

With held

Candidates	Section – D	Section -E	TOTAL
Registered	01	01	02
Appeared	01	01	02
Passed	Nil	01	01

Pass 50%

Sd/-
Dr. G. S. Nadiger
Chairman, PAC

Sd/-
Haresh B. Parekh
Hon. Gen. Secretary

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Schedule of A.T.A. Part-I, II & III December 2021

ATA Part-I	Time: 10.00 a.m. to 1.00 p.m.	ATA Part-II	Time: 2.00 p.m. to 5.00 p.m.
Date	Subjects	Date	Subjects
24.12. 2021	Basic Engineering Sciences	24.12. 2021	Principles of Yarn Manufacture
25.12. 2021	General Engineering	25.12. 2021	Principles of Fabric Manufacture
26.12. 2021	Textile Fibres	26.12. 2021	Principles of Textile Wet Processing
27.12. 2021	Elements of Textile Technology	27.12. 2021	Principles of Textile Testing and Statistics
28.12. 2021	Elements of Comp. and its Applications	28.12. 2021	Industrial Organization and Management

Schedule of A.T.A. Part-III - December 2021

Time: 10.00 a.m. to 1.00p.m

Compulsory Subjects

24.12. 2021	Elements of Technical Textiles
25.12. 2021	Man-Made Fibre Technology

Optional Subjects

Date	Yarn Manufacture Group	Fabric Manufacture Group	Textile Wet Processing Group	Knitting & Garment Manufacture Group
26.12. 2021	Process Control in Yarn Mfg.	Process Control in Fabric Mfg.	Wet Processing-I	Knitting Technology
27.12. 2021	Modern Yarn Manufacture	Modern Fabric Manufacture	Wet Processing-II	Garment Technology

Sd/-
Dr. G. S. Nadiger
Chairman, PAC

Sd/-
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Schedule of G.M.T.A. Examination - December 2021

Section-A	Time 10.00 a.m. to 1.00 p.m.	Section-B	Time: 2.00 p.m. to 5.00 p.m.
Date	Subject No & Title	Date	Subject No & Title
24.12. 2021	A-1 Engineering Physics	24.12. 2021	B-1 Yarn Manufacture
25.12. 2021	A-2 Engineering Chemistry	25.12. 2021	B-2 Fabric Manufacture
26.12. 2021	A-3 Engineering Mathematics	26.12. 2021	B-3 Textile Wet Processing
27.12. 2021	A-4 General Engineering	27.12. 2021	B-4 Apparel Manufacture
28.12. 2021	A-5 Professional Orientation	28.12. 2021	B-5 Textile Testing

Section-C	Time 10.00 a.m. to 1.00 p.m.
Date	Subject No & Title
24.12. 2021	C-1 Textile Fibre Science
25.12. 2021	C-2 Polymer Technology
26.12. 2021	C-3 Textile Engineering Mechanics
27.12. 2021	C-4 Applied Statistics
28.12. 2021	C-5 Data Management and Information System

	Section-D - Time: 2.00 p.m. to 5.00 p.m.			
Date	Yarn Manufacture	Fabric Manufacture	Text. Wet Processing	Apparel Manufacture
24.12. 2021	Short Staple Yarn Mfg.	Advanced Fab. Manufacture	Wet Proc-Pre Treat. & Bleaching	Apparel Technology
25.12. 2021	Long Stap & other Yarn Mfg.	Knitting Technology	Wet Proc.-Dyeing	Supply Chain Mange in Apparel Mfg.
26.12. 2021	Engg Design & Yarn Structure	Engg Design of Fab. Structure	Wet Proc-Printing & Finishing	Apparel Merchandising
27.12. 2021	Process & Qual Management & Yarn Mfg.	Process Control & Qual. Magt. in Fab. Mfg.	Analytical Chem. In Textiles	Garment Proce. Tech.
28.12. 2021	Man-made Fibre Technology	Fabric Structure & Design	Proce & Qual Manage In Wet Proce.	Process Control & Quality Manage in Apparel Mfg.
Optional Papers				
29.12. 2021	Specialty & High Performance Yarns(s)	Non Woven Technology	Colour Theory & Col. Matching	Social & Trade Compliances
30.12. 2021	Silk Reeling & Throwing Technology	Technical Textiles	Effluent Treat & Eco Friendly Proce.	Garment Acces. & Fashion Forecasting
31.12. 2021	Quality & Envir. System in Yarn Mfg.	Quality & Environment Systems In Fab. Mfg.	Quality & Environ System in Wet Proc.	Visual Merchandising

Section-E	Time 10.00 a.m. to 1.00 p.m.
Date	Subject No & Title
27.12. 2021	E-1 Industrial Engg & Mill Management
28.12. 2021	E-2 Energy Environment & Efficiency in Textiles
Optional Papers	
29.12. 2021	EOD-1 International Trade Management
30.12. 2021	EOD-2 Control Systems in Textile Machines
31.12. 2021	EOD-3 Entrepreneurship Development

Sd/-
Dr. G. S. Nadiger
Chairman, PAC

Sd/-
Haresh B. Parekh
Hon. Gen. Secretary

FORTHCOMING EVENTS

ITM 2021
Date : 22nd to 26th June, 2021
Venue : Tuyap Fair Convention and Congress Centre, Beylikduzu, Istanbul
Website : www.itmexhibition.com

Yarnex – India International Yarn Exhibition
Date : 01st & 03rd July, 2021
Venue : Pragati Maidan, Delhi
Contact : S.S. Textile Media Pvt. Ltd.
826, 9th cross, 10th Main Rd, 2nd Stage,
Indiranagar, Bengaluru - 560 038 Karnataka
Tel. : +91-80-25214711, 41151841
Mob. : +91-9845446570
E-mail : sstm@textilefaiarsindia.com
Website : www.textilefairsindia.com

FILTECH 2021
Date : 23rd to 25th August, 2021
Venue : Cologne, Germany
Website : https://filtech.de

ITME India Exhibition 2021
Date : 08th to 13th December, 2021
Venue : IEML, Greater Noida
Contact : India ITME Society,
1210, Dalamal Tower, A Wing, 12th Floor,
211, Nariman Point, Mumbai – 400 021
Tel. : +91-22-4972 4603 / 2202 0032 / 2285 1579
Mob. : +91-9820507570
E-mail : itme@india-itme.com
Website : https://itme2021.india-itme.com/

ITMA 2023
Date : 08th to 14th June, 2023
Venue : FIERA Milano RHO, Milan, Italy
Contact : Ms Daphne Poon, ITMA Services
Mob. : +65 94789543
Email : daphnepoon@itma.com
Website : www.itma.com

Every effort is made to ensure that the information given is correct. You are however, advised to re-check the dates with the organizers.

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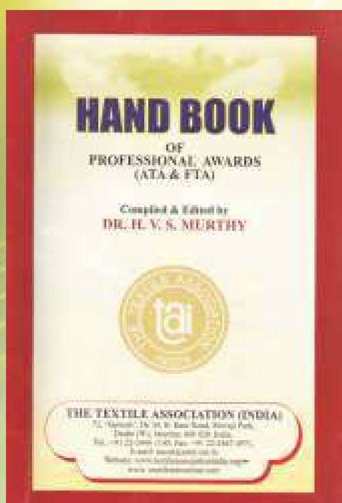
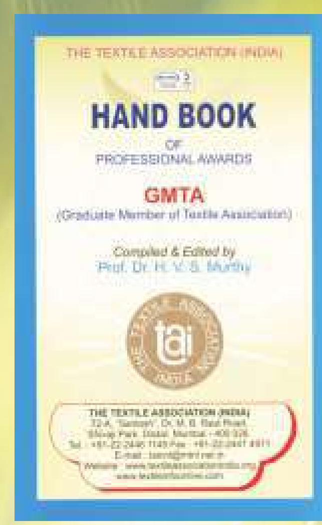


ATA – Associate Member of Textile Association
(Part I,II & III) – 3 years course



GMTA – Graduate Member of Textile Association
(Section A,B,C,D & E) – 5 years course

For more details

Visit us on

www.textileassociationindia.org

or write/contact

The Textile Association (India)

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