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Design and Development of Jacquard Fabrics with Antibacterial Finishes

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Abstract: *In textile industry, with the development of new fabrics, new weaving and finishing techniques, technology has become more systematic in modern times. The fabric and design development in jacquard weave is primarily based on creative science of textile technology. The art of jacquard weaving signifies man's aspiration to combine beauty with utility. Jacquard fabrics of cotton are highly durable, comfortable and good conductors of heat. The jacquard samples were finished with the antibacterial agent "Quaternary ammonium compound". The characteristic of the jacquard fabric after each finish was subsequently studied through Fourier Transform Infrared Spectroscopic analysis (FTIR) and Scanning Electron Microscopic analysis (SEM).*

Keywords: *Woven jacquard fabrics, finishes, antibacterial activity and fabric analysis.*

INTRODUCTION

Modern technology has become more systematic with the development of new fabrics, new weaving and finishing techniques. Various scientific techniques which can allow the designer to possess creative abilities to design a woven product called a creative product have been designed. Newer designs are being introduced to cater to the changing fashion. Microorganisms have the capacity to embed themselves in clothes, in a closet, curtains, carpets, bed, bath, kitchen linens, and even pillows and mattresses. Many bacteria live on the skin while dust mites live on shed human skin cells that have been deposited on items such as sheets, towels, clothing, etc. Antibacterial textiles continue to gain popularity because of their fresh smelling, skin friendly, and high performance nature.

To start the research work, a market survey has been conducted to study the jacquard fabric designs and 15 novel designs have been created by CAD system and all 15 samples are newly developed. The antibacterial finish has been given to all the 15 newly developed jacquard designed fabrics of cotton with 30^s count.

Development of Antibacterial Finished Jacquard Fabrics

The growth of microorganism on textile material is an important factor that has resulted in the development of antibacterial finish to fabrics. Microbial infestation poses danger to both living and non-living matters. Microorganisms cause problems in textile raw materials and processing chemicals, wet processes in the mills, roll or bulk goods in storage, finished goods in storage and transport, and goods as the consumer uses them.

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Assessment of Efficiency of Antibacterial Finished Jacquard Fabrics

The jacquard fabrics finished with the antibacterial agents were tested for their efficiency by performing agar diffusion method (EN ISO 20645). The antibacterial activity was identified by zone of inhibition in mm against test organisms after 24 hours of incubation. Table 5.1 shows the assessment of efficiency of antibacterial finish.

Antibacterial Testing for the Finished Jacquard Fabrics

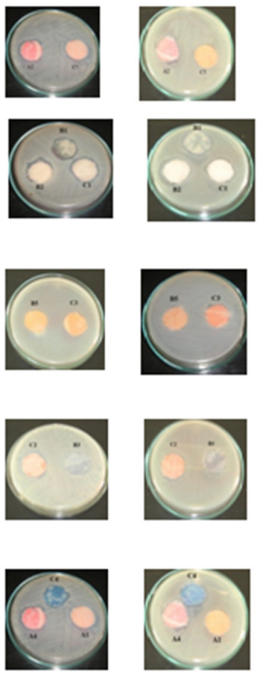
S. No.	Sample No.	Antibacterial activity (Zone of Bacteriostasis – mm)	
		Escherichia coli	Staphylococcus aureus
1	A1	24	30
2	A2	25	27
3	A3	28	28
4	A4	30	28
5	A5	35	25
6	B1	33	26
7	B2	30	26
8	B3	27	27
9	B4	33	29
10	B5	22	22
11	C1	29	28
12	C2	28	30
13	C3	22	25
14	C4	30	28
15	C5	27	26

From the table, it is evident that in first set of samples namely A1 – A5, the maximum zone of inhibition for E.coli is found to be 35 mm with sample A5 and for S.aureus was found to be 30 mm with sample A1. The minimum zone of inhibition is found to be 24 mm for S. aureus (A1) and 25 mm for E.coli (A5).

In the second set of samples namely B1 – B5, the maximum zone of inhibition for E.coli is found to be 33 mm for sample B1 and B4 and 29 mm for S.aureus for sample B4. Fabric B5 has minimum antibacterial activity against both E.coli and S.aureus.

Antibacterial Activity of the Finished Fabrics by EN ISO 20645

Escherichia coli Staphylococcus aureus



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In the third set of samples namely C1 – C5, the maximum zone of inhibition for E.coli is found to be 30mm for sample C4 and for S.aureus is found to be 30 mm for C2. The minimum zone of inhibition is found to be 22 mm for S.aureus(C3) and 25 mm for E.coli (C3). The photographs of the antibacterial activity on the finished fabrics are given in plate 5.1.

Selection of Antibacterial Finished Jacquard Fabrics with Maximum Efficiency for Multifunctional Finish

Based on the assessment of efficiency of antibacterial finish, the fabric which showed good antibacterial effect such as two fabric samples from every set (A4, A5, B1, B4, C2 and C4) was selected for antibacterial finish. The nomenclature of the sample is tabulated as follows.

S. No.	Nomenclature of the samples	Design description
1.	Snow creep fabric (A4)	Dark blue colour with orange flower motif
2.	Fiery sky fabric (A5)	Dark grey colour with flower motif
3.	Sandy flow fabric (B1)	Dark colour with flower motif
4.	Lime yellow fabric (B4)	Light green colour with flower motif
5.	Peacock gold fabric (C2)	Blue and yellow colour with flower motif
6.	Tripetals fabric (C4)	Red and green colour with flower motif

Testing of Finished Jacquard Fabrics for Physical Properties

Physical properties such as fabric weight, abrasion resistance, tensile strength, and colour fastness were studied for the fabric to which finish was given. The fabric which showed good antibacterial effect, such as the two fabrics from every set was taken for physical testing and their results are given in the table. The following table gives the result for fabric weight of the antibacterial finished jacquard fabrics.

Fabric Weight of Antibacterial Finished Jacquard Fabrics

S. No.	Sample	Untreated fabric weight mean (GSM)	Finished fabric weight mean (GSM)	Gain over original	Percentage of Gain
1.	A4	209	218	09	4.31
2.	A5	272	285	13	4.78
3.	B1	208	225	17	8.17
4.	B4	219	231	12	5.48
5.	C2	175	187	12	6.86
6.	C4	200	209	09	4.50

From the table, it is clear that after antibacterial finish, the fabric weight has increased in the range of 4.31percent to 8.17percent due to the application of finish on the surface of the fabrics. The weight of the Sandy flow fabric (B1) has gained maximum of 8.17 percent and Fiery sky fabric (A5) has gained minimum of 4.31 percent. The fabric weight of antibacterial treated and untreated fabrics were subjected to F test, the value obtained is 0.410 and it is not significant at 1% and 5% level.

S. No.	Sample	Sample weight before abrasion (grams)		Sample weight after abrasion (grams)		Loss over original		% of abrasion resistance	
		Un treated	Treated	Un treated	Treated	Un treated	Treated	Un treated	Treated
1	A4	0.25	0.28	0.23	0.26	-0.02	-0.02	8.0	7.14
2	A5	0.33	0.36	0.32	0.35	-0.01	-0.01	3.03	2.77
3	B1	0.26	0.29	0.24	0.27	-0.02	-0.02	7.69	6.89
4	B4	0.26	0.29	0.24	0.28	-0.02	-0.01	7.69	3.45
5	C2	0.24	0.26	0.21	0.23	-0.03	-0.03	12.5	11.54
6	C4	0.27	0.30	0.26	0.29	-0.01	-0.01	3.7	3.33

From the table, it is clear that all the samples treated with antibacterial finish lost its abrasion in the range of 2.77 to 11.54 percent. Maximum loss occurs in sample (C2) due to the smoothness of the fabric surface. When compared to untreated samples, abrasion

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resistance percentage decreased after imparting antibacterial finish. The abrasion resistance of antibacterial treated and untreated fabrics is subjected to F test; the value obtained is 0.405 and it is not significant at 1% and 5% level.

Tensile Strength and Elongation (Warp) of Antibacterial Finished Jacquard Fabrics

S. No.	Tensile Strength (Warp)					Elongation			
	Sample	Untreated fabric mean (Kg/cm^2)	Finished fabric mean (Kg/cm^2)	Loss over original	% of Loss	Untreated fabric mean (cm)	Finished fabric mean (cm)	Gain over original	% of Gain
1.	A4	73.6	72.4	-1.2	1.63	4.2	4.4	0.2	4.76
2.	A5	72.1	70.6	-1.5	2.08	4.0	4.2	0.2	5.0
3.	B1	38.2	36.4	-1.8	4.71	3.7	4.0	0.3	8.11
4.	B4	46.7	44.9	-1.8	3.85	2.8	2.9	0.1	3.57
5.	C2	58.1	56.6	-1.5	2.58	2.5	2.7	0.2	8.00
6.	C4	47.2	46.4	-0.8	1.69	2.6	2.8	0.2	7.69

From the table, it is clear that the tensile strength of the fabric along the warp direction is lost after antibacterial finish and it ranges from 1.63 to 4.71 percent, whereas the elongation of all the samples have increased in the range of 3.57 to 8.11percent. Maximum strength loss along the warp direction is 4.71 percent for (B1) due to its high absorbance of antibacterial finish and minimum strength loss of 1.69 percent for (C4). The maximum elongation capacity of 8.11 percent is found to be for fabric (B1). The minimum elongation capacity of 3.57 percent is found to be for (B4) fabric.

The tensile strength (weft) of antibacterial treated and untreated fabric is subjected to F test, the value obtained is 0.029 and it is not significant at 1% and 5% level. The elongation values of antibacterial treated and untreated fabric is subjected to F test, the value obtained is 0.204 and it is not significant at 1% and 5% level.

Tensile Strength and Elongation (Weft) of Antibacterial finished Jacquard Fabrics

S. No.	Tensile Strength (Weft)					Elongation			
	Sample	Untreated fabric mean (Kg/cm^2)	Finished fabric mean (Kg/cm^2)	Loss over original	% of Loss	Untreated fabric mean (cm)	Finished fabric mean (cm)	Gain over original	% of gain
1.	A4	38.7	37.2	-1.5	3.88	5.8	5.9	0.1	1.72
2.	A5	37.6	36.6	-1.0	2.66	5.6	5.8	0.2	3.57
3.	B1	13.6	12.7	-0.9	6.62	3.0	3.3	0.3	10.0
4.	B4	37.2	35.6	-1.6	4.30	2.7	2.9	0.2	7.41
5.	C2	30.2	28.4	-1.8	5.96	2.9	3.0	0.1	3.45
6.	C4	38.6	37.7	-0.9	2.33	3.0	3.3	0.3	10.0

From the table, it is clear that the tensile strength along the weft direction of all the fabrics has lost after antibacterial finish in the range of 2.33 to 6.62 percent, whereas, the elongation of all the fabrics have increased in the range of 1.72 to 10 percent. Maximum strength loss along the weft direction was 6.62 percent for (B1) due to its loose structure of fabric and minimum strength loss of 2.33 percent for (C4). The maximum elongation capacity of 10 percent is found to be for the fabrics (B1) and (C4). The minimum elongation capacity of 1.72 percent is found to be for A4 fabric.The tensile strength (weft) of antibacterial treated and untreated fabrics were subjected to F test, the value obtained is 0.051 and it is not significant at 1% and 5% level. The elongation (weft) values of antibacterial treated and untreated fabric were subjected to F test; the value obtained is 0.058 and it is not significant at 1% and 5% level.

Colour Fastness Test of Antibacterial Finished Jacquard Fabrics

S. No	Sample	Sun light	Washing		Crocking				Perspiration			
					Dry		Wet		Acid		Alkaline	
			Cc	Cs	Cc	Cs	Cc	Cs	Cc	Cs	Cc	Cs
1	A4	5	5	5	5	5	5	5	5	5	5	5
2	A5	5	5	4/5	5	4/5	4/5	4/5	4/5	4/5	4/5	4/5
3	B1	5	5	5	5	5	5	5	5	5	5	5
4	B4	4/5	5	4/5	5	4/5	5	4/5	4/5	4/5	4/5	4/5
5	C2	5	5	5	5	5	5	4/5	5	5	5	4/5
6	C4	4/5	5	5	5	4/5	4/5	4/5	4/5	4/5	4/5	4/5

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From the above table it is clear that, the colour fastness property for (A4) and (B1) has excellent grade for sunlight test, washing test, crocking test by dry and wet method and perspiration test by acid and alkali treatment. The colour fastness property for (A5), (B4), (C2) and (C4) have very good grade for sunlight test, washing test, crocking test by dry and wet method and perspiration test by acid and alkali treatment.

The above tables from 5.2 to 5.7 represents the physical properties of the antibacterial finished fabric such as fabric weight, abrasion resistance, tensile strength and colour fastness. After studying the physical property, it is clear that the sample B1 has maximum gain in fabric weight, elongation and loss of tensile strength due to the antibacterial finish. Hence the characterization of finished fabric B1 is analyzed by FTIR and SEM.

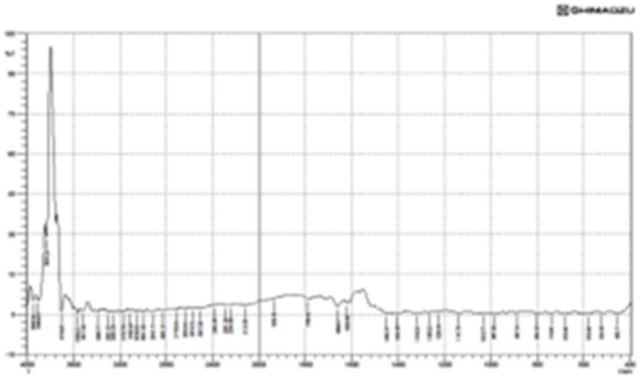
Characteristics of Antibacterial Finished Jacquard Fabric by FTIR and SEM Analysis

From the six pieces of jacquard fabrics finished, the best and efficient fabric of antibacterial finish (B1) is taken for characterization study by FTIR and SEM analysis.

Fourier Transform Infra Red Spectroscopic (FTIR) Analysis

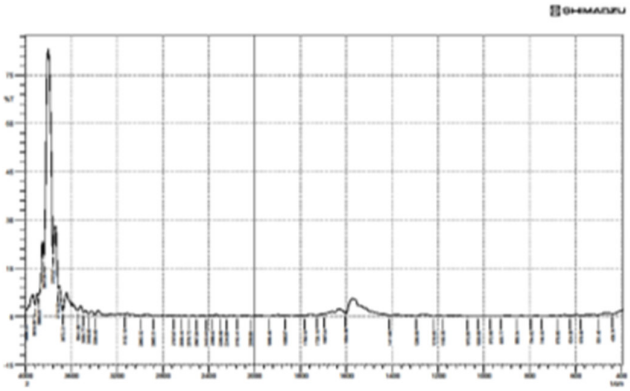
The samples were analyzed for their variations in chemical groups using FTIR spectroscopy and the results were compared for further analysis.The characteristic of the finished Sandy flow fabric (B1) was tested and the result was compared with the control (unfinished) fabric by Fourier Transform Infra Red Spectroscopic analysis (FTIR).

Figure 5.7 Fourier Transform Infrared Spectrogram (FTIR) of Untreated Jacquard Fabric



The FTIR analysis of untreated jacquard fabric is presented in the above figure. The results indicated the presence of peaks at wavelengths of 3949.94, 3903.66, 3834.22, 3703.07, 3517.92, 1658.67, 3517.92, 1620.09 cm^{-1}. The absorption in the region 3200 cm^{-1} to 3600 cm^{-1} may correspond for O-H structure and absorption in the region 1200 $cm^{-1}$and 1000 cm^{-1} may corresponds to C-O structure or O-H that confirms the presence of hydroxyl group.

Fourier Transform Infrared Spectrogram (FTIR) of Antibacterial Finished Jacquard Fabric



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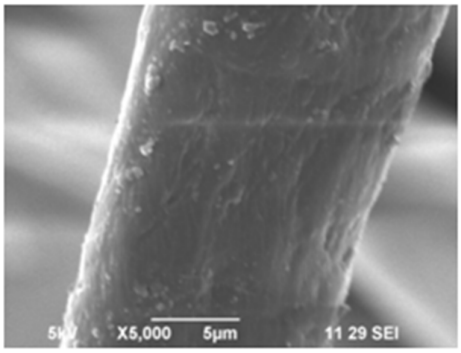
The FTIR analysis of antibacterial finish jacquard fabric is presented in the above figure. The results indicated the presence of peaks at wavelengths of 3911.37, 3880.51, 3826.51, 3772.50, 3548.78, 3355.91, 3294.19, 3703.07, 2414.71, 1596.95 cm^{-1}. Of these peaks, the one at 3911.37, 3880.51, 3826.51, 2414.71, 1596.95 cm^{-1} was very sharp and broad compared to the other peaks indicating the high concentration of the antibacterial agent at these regions. The O-H stretching band in carboxyl groups is very broad and span between 3100-2400 cm-1 overlapping with a significant number of peaks that we quantify. To resolve the shape of peaks within this type of spectra, we retrieved a series of carboxylic acids with varying quantities of aliphatic C-H and COOH groups.

Scanning Electron Microscope (SEM) of Antibacterial Finished Jacquard Fabric

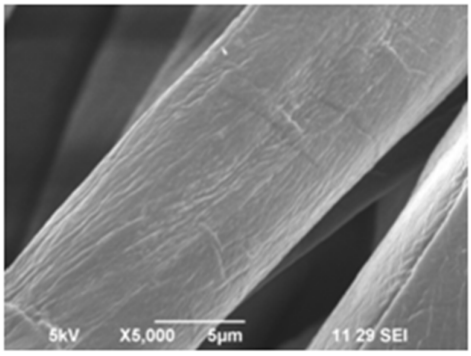
The surface topography of the finished fabric was observed with a scanning electron microscope (SEM). The characteristics of the finished fabric are tested and the results were compared with the control (unfinished) fabric.

Scanning Electron Microscopy (SEM) Image of Untreated Fabric



The above figure shows the scanning electron microscopic image of untreated jacquard fabric. The imaging is done at 5, 000 X magnifications and 5 KV. The above figure is the image of untreated fabric's yarn, which is approximately 15 µm in breadth with rough surface.

Scanning Electron Microscopy (SEM) Image of Antibacterial Finished Jacquard Fabric



The above figure shows the scanning electron microscopic image of antibacterial finish on jacquard fabric. The imaging is done at 5, 000 X magnifications and 5 KV. The uniform deposition of the finished chemicals is seen clearly on the surface of the yarn.

Conclusion

From the test results of the antibacterial finished jacquard fabrics, the best six fabric samples, two representing each set are selected and used for multifunctional finishing and testing and then, the characteristics have been studied. Out of the best six samples, (B1) has got maximum absorbency of antibacterial finish, because of its fabric structure (surface thickness). After imparting all the physical tests, sample (B1) is taken for FTIR test and SEM analysis. It shows the presence of finished chemicals and uniform application of the antibacterial finish on the surface of the fabric.

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