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ENHANCING ANTIBACTERIAL PROPERTY OF WOOL FABRIC

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ABSTRACT

Textile materials are not only the carriers of microorganisms such as pathogenic bacteria, odour generating bacteria and fungi, but also good media for growth of microorganisms. Antibacterial fabrics are not only important in medical application but also in daily use conditions. Antibacterial finish prevents the growth of bacteria, thus protecting health and preventing diseases. In present study lab prepared silicone finish (F1), lab prepared silicone finish with chitosan (F2) were developed and applied on wool fabric by pad-dry-cure method for enhancing antibacterial properties. Untreated and treated wool fabric samples were tested for antibacterial activity against Staphylococcus aureus and were compared with an antibacterial commercial finish by AATCC test method 90-2011. Physical properties: stiffness, crease recovery angle and tensile strength were also evaluated. Result showed that the antibacterial efficacy of the lab prepared silicone finished (F1) on wool was better than commercial antibacterial finish (F3). The antibacterial efficiency of chitosan mixed silicone finish (F2) was found to be better than the lab prepared silicone finish. Thus, Chitosan provides higher functionality to wool fabric against microbes.

Keywords: ***Antibacterial, chitosan, silicone finish, wool.***

INTRODUCTION

To impart the required functional properties to the fiber or fabric, it is customary to subject the material to different types of physical and chemical treatments. Finishing is the final processing of the cloth and its purpose is to make the fabric suitable for its intended end use. Textile finishes and finishing are classified in several ways. Usually categorized as aesthetic and functional finishes [1]. These days due to specific use and requirements of consumers, special purpose finishes are gaining importance. Of these, antibacterial finishes are one of them.

Microbes such as bacteria, viruses and fungi are present almost everywhere. Human beings have an immune system to protect against accumulation of microorganisms but materials such as textiles can easily be colonized by high numbers of microbes or even decomposed by them. Textiles are carriers of microorganism such as pathogenic bacteria, odour – generating bacteria, mould and fungi. Antimicrobials enhance the functionality and value of textile products by keeping the microorganism that cause odour and fiber degradation under control. The application of antimicrobial textile finishes include a wide range of textile products for medical, industrial, home furnishing and apparel sectors [2].

Natural and synthetic fibers vary greatly in their response to microbial growth. Both may act as willing substrates but the mechanism in the two cases is very different. Natural fibers are easy targets for microbial attack because they retain water readily and microbial enzymes can readily hydrolyze their polymer linkages. Cotton, wool, jute and flex are reported to be most susceptible to microbial attack [3].

Chitosan is a natural polycationic polysaccharide derived from chitin, which is found in the crustacean's shells, insect's cuticle and cell wall of fungi. Chitosan possesses antimicrobial activity and filmogenic properties, besides being biocompatible and biodegradable [4].

In the recent past some studies have been reported on antibacterial finishing of textile fabrics. Combination of chitosan with citric acid and silicone softener was studied by Karolia and Mendapara (2007) to impart antimicrobial and fragrance finish on cotton fabric to improve its functional properties [5]. Thilagavathi and Kannaian [6] have reported antimicrobial efficacy and blood repellency of the sputter deposited Teflon fabrics to be better than the fluropolymer treated fabrics. Sathianarayanan et al., [7] have found that herbal extracts from *Ocimum sanctum* (tulsi leaf) and rind of *punica granatum* (pomegranate) show good and durable antimicrobial properties on cotton by micro-encapsulation and resin cross-linking treatment.

In the present study two silicone based antibacterial finishes were prepared in laboratory, and applied on wool fabric using pad-dry-cure method. The prepared finishes were evaluated against a commercial finish. Physical properties of untreated and treated wool fabric like stiffness, crease recovery angle and tensile strength were also studied.

MATERIALS AND METHODS

2.1 Materials:

The wool fabric used for the study was 100%. Commercial antibacterial finish specifically ment for textile was procured from an industry.

2.2 Methods:

2.2.1 The procured wool fabric was thoroughly scoured, using standard method and air dried.

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2.2.2 Identification (AATCC test method 20-2007):

Confirmation of the fiber type was done through microscopic analysis, burning test and chemical solubility test [8].

2.2.3 Determination of preliminary data:

Preliminary data including fabric structure (weave), fabric count (the number of yarns/inch) helped to describe the tightness of the weave, fabric width, weight per unit area, thickness were determined using standard methods [10] which are given in Table-1.

Table -1: Preliminary data of fabric:

Fabric	Weave	Yarn count (inch)		Fabric Width (cm)	Weight per Unit area (gms/sq.mtr)	Thickness (mm)
		Warp	Weft			
Wool	Twill	66	60	136	272.0	0.68

2.2.4 Preparation and application of finish:

Silicone finish (F1) was prepared in the laboratory under controlled conditions using laboratory grade reagents. The finish (50g/l) was prepared as per recipe given in Table - 2. Wool fabric was finished by pad (2min)-dry (10 min) (4 times) iron-cure, (3 minutes at 110°C temperature) sequence.

Table -2 Recipe for lab prepared finish:

Epoxide (with known molecular weight)	Optimum quantity (Total volume 50 gpl, padding)
Tri Methyl Silyl Chloride	
Cetyl Tri-methyl Ammonium Bromide	
Tri Ethyl Amine	
Solubilising agents: (Poly Ethylene Glycol, Benzene, Methanol, Water)	

Silicone finish with chitosan (F2) was prepared in the laboratory under controlled conditions using laboratory grade reagents. Chitosan ($C6H11O4N$)n was dissolved in 1 % acetic acid solution and soaked overnight to make a homogeneous mixture. 1% chitosan solution was added to F1 finish (recipe given in Table - 2) and blended well. Commercial antibacterial finish was prepared by using product application guide (Table - 3) [9].

Table-3 Conditions for application of commercial finish:

Concentration of finish	0.60 %
% pick up	57.14
Dosage in gpl	8.6
MLR (material to liquor ratio)	1:10
pH of bath-adjust	6.0-6.5
Bath temperature	Room temp (25 to 40°C)
Process time	30 minutes
Drying	120°C

2.2.5 Determination of Antibacterial property:

The antibacterial properties of samples were evaluated qualitatively by measuring the width of a clear zone of inhibition around the samples by (AATCC test method 90-2011) [11] antibacterial activity assessment of textile materials: agar plate method. In order to evaluate the antibacterial properties, specimens of the test material including corresponding untreated controls of the same material were placed in intimate contact with the agar which had been previously seeded with an inoculamns of a test bacterium. After incubation a clear zone of interrupted growth underneath and /or adjacent to the test material indicates antimicrobial activity of the specimen. A standard strain of S-aureus bacteria was used.

The average width of a zone of inhibition on either side of the specimen was calculated using the following equation.

$$W = (T-D) / 2$$

Where, W is width of clear zone of inhibition in mm

T is total diameter of test specimen and clear zone in mm

D is diameter of the test specimen in mm

The durability of finish was also evaluated by giving one wash and ten washes and then observing antibacterial property of the fabric samples.

2.2.6 Effect of finish on physical properties of the fabric:

2.2.6.1 Evaluation of Stiffness:

The samples were evaluated for stiffness using standard test method [9]. Eureka stiffness tester was used, five warp and five weft specimens of size 6 x 1 inches were placed on the instrument and the scale was slided till the edge of the sample was in line with the line in the reflection mirror. The reading on scale was taken and average was recorded.

2.2.6.2 Evaluation of crease recovery angle:

To determine crease recovery by AATCC test method 66-1975 [8]. Eureka make crease recovery tester was used. Five warp and five weft specimen of 50 x 25 mm size were cut and placed in a loading device one at a time for five minutes under a pressure of 5oo gms after being folded in half. The folded sample was then placed in a crease recovery tester which allowed the fabric to unfold, the recovery of fabric after five minutes was noted, and average has been recorded.

2.2.6.3 Evaluation of tensile strength:

The strength of the samples was determined using elongation at break and breaking load using standard test method [9]. Fully computerized Lloyd LRX was used. Five warp and five weft samples of size 15 x 1 cm were cut and loaded on the instrument. The instrument was run and direct readings were obtained.

3. RESULTS AND DISCUSSION

3.1 Antibacterial effect on the fabric:

S. aureus (gram positive) bacteria were used for antibacterial testing as it is the main cause of skin disease and body odour. Antibacterial activity was evaluated by observing the clear zone. The observations are given in (Table 4). Over all it was observed that the lab prepared silicone finish (F1), lab prepared silicone finish with property enhancing agent chitosan (F2) and commercial antibacterial finish (F3) improved the antibacterial properties of the wool fabrics used in the study. Result reveal that in case of untreated wool fabric also slight clear zone is observed because the outer layer of wool fibers have a high concentration of fatty acids, which have natural antibacterial properties. Wool fabric treated with the lab prepared silicone finish (F1) shows 15.8 mm clear zone, i.e. the bacterial growth was seen 15.8 mm away from the sample. Whereas in lab prepare silicone finish with chitosan (F2) no growth of bacteria was observed. Commercial finish (F3) was less effective than lab prepared (F1) and chitosan mixed (F2) finish.

The durability of all finish was also evaluated, it was found to be good as washing has not influenced the effectiveness of finish, moreover, after washing antibacterial property of lab prepared finish (F1) improved further and no growth of bacteria was observed after one wash and after ten washes also. This could be attributed to the influence of soap present in the wash liquor.

Table-4: Antibacterial properties of untreated and treated fabrics:

Wool	w (width of clear zone of inhibition in mm)		
	Unwashed	1 Wash	10 Wash
Untreated (F0)	0.50	0.50	0.50
Lab prepared finish (F1)	15.80	NG	NG
Lab prepared finish+ Chitosan (F2)	NG	NG	NG
Commercial anti bacterial finish (F3)	1.16	1.00	1.00

Abbreviations used: NG =No growth.

3.2 Physical properties of the fabric:

Finishes were evaluated to study their influence on stiffness (bending length), crease recovery and tensile strength properties.

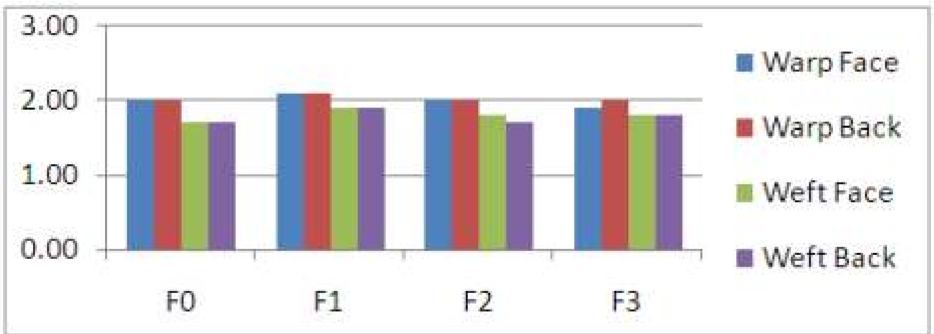
3.2.1 Effect on stiffness:

Details of stiffness are presented in Table-5 and Fig.1, comparing the stiffness result of untreated and treated samples; it was observed that, the finishes do not show any significant influence in warp/weft, face/back stiffness of the treated samples

Table-5: Physical properties of untreated and treated fabrics:

Wool	Stiffness(cm)				Crease Recovery (degrees)				Tensile Strength (elongation at break)			
	Warp		Weft		Warp		Weft		Warp		Weft	
	Face	Back	Face	Back	Face	Back	Face	Back	Load	Elongation	Load	Elongation
Untreated (F0)	2.00	2.00	1.70	1.70	31.60	28.60	16.00	13.60	9.38	22.56	8.75	22.75
Lab prepared silicone finish (F1)	↑2.10	↑2.10	↑1.90	↑1.90	↑37.00	↑30.60	↑18.30	↑15.30	↑9.91	↑27.23	↓8.48	↑22.83
Lab prepared silicone finish + Chitosan (F2)	=2.00	=2.00	1.80	=1.70	↑32.20	↓26.80	↑19.60	↑17.00	↓8.18	↓20.45	↓7.87	↓19.92
Commercial antibacterial finish (F3)	↓1.90	=2.00	↑1.80	↑1.80	↓30.80	=28.60	↑24.20	↑20.60	↓8.33	↑22.86	↓6.89	↓21.84

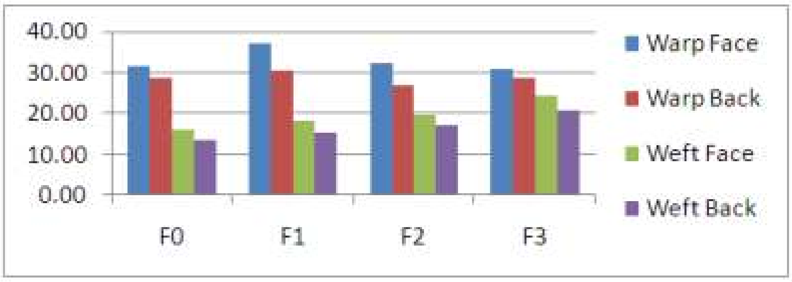
Figure-1: Stiffness (cm) of untreated and treated fabrics



3.2.2 Effect on crease recovery angle:

The crease recovery readings of all the samples are presented in Table - 5 and Fig. 2. There has been significant improvement in crease recovery of all lab prepared silicone finished (F1) fabric. After adding chitosan in silicone finish (F2) the crease recovery of warp/back side has decreased otherwise warp face side and weft face and back side have increased in comparison with untreated wool fabric. In case of commercial antibacterial finished fabrics crease recovery for warp-face side has decreased while for warp-back side it has remained unchanged. For weft-face and back it has slightly improved.

Figure-2: Crease recovery (degree) of untreated and treated fabrics



3.2.3 Effect on tensile strength:

Load and elongation of warp and weft have been presented in Table-5 and Fig.3 and 4. On comparing the readings of untreated and treated samples it was observed that the breaking load and elongation at break of lab prepared silicone finished samples has increased. In case of fabric finished with lab prepared silicone with chitosan and commercial antibacterial finish tensile strength has decreased except warp elongation for commercial finish.

Figure-3: Load at break (kg) of untreated and treated fabrics

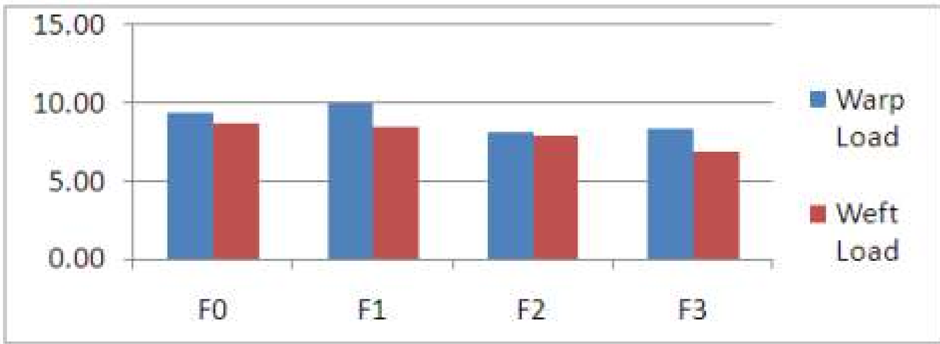
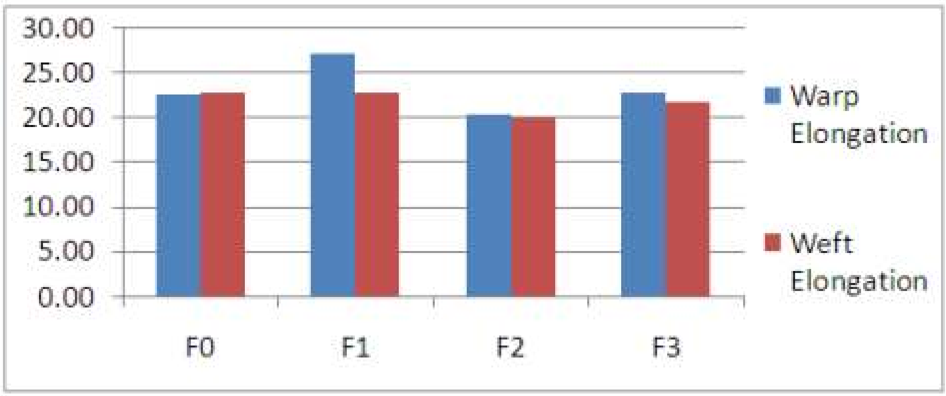


Figure-4: Elongation at break (mm) of untreated and treated fabrics



4. CONCLUSION

The antibacterial efficacy of the lab prepared silicone finish (F1) on wool fabric was more in comparison to commercial antibacterial finish. The antibacterial efficiency of chitosan mixed silicone finish (F2) on wool was found to be better than the lab prepared silicone finished fabric. In short the antibacterial property of finishes on wool can be represented as F2 > F1 > F3. Addition of chitosan in silicone finish provides higher functionality and better performance to wool fabric. It is important to note that the physical properties studied, stiffness, crease recovery angle and tensile strength have not shown any drastic change due to the finishes used.

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