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Silane Modified Quaternary Ammonium Chloride Mediated Hygienic Uniform Fabrics

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Abstract

This study aims to develop uniform fabrics for different industrial environments. The study also saw the types and effects of microbes as well as chemicals used to protect the uniform fabrics against their attack under the environment of different corporate industries. This work reports the influence of Alkoxy alkylsilyl dimethyl octadecyl ammonium chloride on anti-bacterial properties of cotton (C), polyester/cotton (P/C) and polyester/viscose (P/V) blended fabric samples. Fabric samples were treated with silane modified dimethyl octadecyl quaternary ammonium chloride compound by the pad-dry-cure method. The influence of this treatment on treated fabrics in terms of antimicrobial activity was measured as per AATCC 100 quantitative method. Improvement in the anti-bacterial activity was observed for all the fabric samples but the improvement in cotton fabric is worth mentioning. This work is a sincere attempt to prepare hygienic common textiles at economical rates using continuous application technique which offers durable efficacy against the human pathogenic bacterium.

Keywords: Human pathogenic bacterium; AATCC TM 100; Uniform fabrics; Antibacterial efficacy

Introduction

Worldwide awareness in retail buyers about leaving healthy and hygienic life increases the demand for antimicrobial/antibacterial textiles. The antibacterial "feature" is quickly moving to a standard requirement for the products that they buy for day-to-day life. Manufacturers who don't currently treat fabrics with a durable antimicrobial finish should consider shielding their products from eroding value by incorporating microbial control agent. As manufacturers look to enhance the value of their products, they should recognize antimicrobial finishes as a feature with a future and the future is now [1]. Textile consumers all around the world are now becoming much more aware of the deleterious effects that micro-organisms may have upon textiles and upon human hygiene. Textiles are one of the main bacteria-carrying mediums. Textile fibres provide the perfect platform for the growth of microorganisms. Even different environments (hot, humid, and cold) lead to the growth of different bacteria. These bacteria/microbes on textiles often result in staining, decoloring of the fabric, and lead to bad odour [2-4].

In tropical countries like India, sweating bad odor on textiles is a common problem for the wearer, especially living in coastal cities. This has aggravated due to polyester-rich blends and global warming. Consumers are looking for garments free from bad odor at the end of the day so that the frequency of washing would be reduced apart from the comfort factor. The problems caused by microorganisms have been widely aired in the media in Western Europe & North America and the medical textile sector, in particular, has welcomed the greater applicability of antimicrobial finishes to stem the presence of the microorganism. In the technical textile sector, antimicrobial finishes are recognized as very beneficial in preventing bio-deterioration of technical textiles, particularly of natural fibres, caused by the growth of moulds, mildew or rot-inducing fungi on the textiles when exposed to weathering. Another area of concern is the growth of microbes and dust mites in floor covering and the general protection of the consumer from insects and other pests. While there has been increasing awareness of hygiene issues and greater consumer demand for hygienic products there is also the wider issue of the presence of antimicrobials that may meet the human body [5-12].

Requirements for corporate industrial uniform fabrics

Uniform garment wearers are exposed to an environment where there is microbial cross-contamination be it in schools, hospitals, pathological labs, food processing, milk processing, hotels, airline companies, IT companies, etc. This further aggravates microbial growth. Above microbial growth on uniform

textiles and textiles in general causes problems like bad odour, itching, yellowing and rapid deterioration of such textile products.

Hospitals and pathological labs are the breeding ground for microbes due to blood, body fluids, stools, urine, etc. Medical workers especially doctors and medical staff are prone to contaminating their clothing with these microbes. Anti-bacterial fabrics prevent the growth and spreading of such bacteria and ensure that doctors and patients alike are saved from the so-called hospital-generated diseases ("Nosocomial infections"). Nosocomial infections occur because of harmful bacteria present in the environment and fabrics in hospitals. The anti-bacterial fabric also finds special importance in the hospitality sector where freshness, cleanliness, and personal hygiene are of paramount importance [13-16].

Employees working in food processing, dairy etc. would normally stain their garments with food product/milk. This would result in cross-contamination of the food products being processed. For example, there are select few microbes which are active in hotel environment, milk processing environment, etc. Bacterial growth and spread because of foods in restaurants and hotels lead to staining and foul odor from the garments. In such a scenario, fabrics can generate great interest and demand among chefs.[13] Similar is the case in dairy industry where regular contact of the garment with milk leads to growth of bacterial activity which can be avoided using antibacterial fabric [13,17-19]. Textile products like undergarments, home textiles, kids wear, medical textiles, sportswear, etc. come in intense contact with human skin. Hence, they are likely to be soiled with human dead skin, sweat/ body fluids, dirt from the environment, residual detergent, different finishes, etc. which form food for bacterial growth. Also, perspiration causes the growth of bacteria and leads to discomfort and smell. Hence, uniforms made from antimicrobial fabric by uniform suppliers in Indian sure freshness and improved performance by school children, industrial and corporate workers alike [3,13].

To benefit from the consumer demand for antimicrobial/ antibacterial products and the antibacterial and antifungal performance needs of the textile world, manufacturers have a choice. In choosing, they should utilize a treatment that provides for an odor reduction/antibacterial claim and an antimicrobial finish for their textile products consistent with their claims and the needs of their target consumers. This selection should be done by considering:

a) Adopting an antimicrobial technology with a proven history of use. This will help shorten the timelines in bringing products with an antibacterial/antifungal/odor-reducing, antimicrobial feature to market.

b) Adopting a non-leaching antimicrobial that doesn't pose the risk of crossing the skin barrier. If it creates a "zone of inhibition" it leaches or moves and has the potential to cause problems.

c) Adopting a non-leaching antimicrobial that could provide durable resistance against microorganisms.

d) Adopting an antimicrobial technology that can have its proper application tested for at the mill or the retailers. A verifiable quality assurance program should be a key component of any application process.

e) Adopting an antimicrobial technology that has technical and marketing support [1].

The bio-deterioration of textile fibres caused by microorganisms including bacteria, fungi, and algae present in the air, water, and soil can cause multiple problems for textile products. Changes in textile colours and in physical properties such as breaking strength, elongation, and elasticity negatively affect the applicability value of textiles from a hygienic and aesthetic point of view. In the last few decades, the prevention of microbial attacks on textile and wearers of textile materials has become increasingly important to consumers and textile producers. For instance, a market study in Germany revealed a steady increase in the demand for antimicrobial fabrics. Therefore, with a rising interest in personal health and hygiene, textiles with antimicrobial properties are becoming an increasingly desirable aim of textile manufactures [18,19]. In our earlier research, [20] antimicrobial efficacy of Corporate Uniform against Human Pathogenic Bacterium by Bio-Burden Test was reported. In the present investigation, silane based quaternary ammonium chloride *(Zycrobial)* was applied on Polyester/Viscose, Polyester/ Cotton blend, and 100% Cotton fabric by pad–dry-cure method. Efficacy of the treated textiles against potentially found bacteria in the different industrial environment was evaluated by quantitative test- AATCC TM 100. The efficacy of the treatment was also evaluated for durability for 10, 20, and 30 wash according to the standard method.

Materials

Fabrics

The three types of fabrics were selected for uniform fabrics namely, Polyester/Viscose (P/V), Polyester/Cotton (P/C) blend, and 100% Cotton (C). The detailed specifications for fabrics are given in Table 1.

Chemicals

Alkoxy alkylsilyl dimethyl octadecyl ammonium chloride *(Zycrobial)* supplied by Zydex industries limited, Vadodara was used throughout the study. Other chemicals viz., acetic acid, non-ionic detergent (R-77), and sodium carbonate were used supplied by Zydex Industries limited. The ECE reference detergent (Non-ionic and without optical brightener) supplied by Kiran threads, Vapi was used for BS EN 26330:1994 domestic washing method. All chemicals used in this experiment were of analytical grade and used without further purification.

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Table 1: Specification of various fabrics.

Test	Fabrics		
	P/V	P/C	C
Weave	Plain	Plain	2/1 Twill
Blend (%)	80/20	67/33	100% C
GSM	175.24	119.57	246.77
EPI/ PPI	58/50	100/76	78/53
Count/Denier	416/380	161/155	14.8/11.5
Width (cm)	148.5	92	152
Thickness (mm)	0.38	0.3	0.62

Experimental Methods

Antimicrobials application methodologies

Preparation of textile fabrics for treatment: To remove the finish and other hydrophobic impurities from all the three selected fabrics. The fabrics were treated with the bath containing 5 gpl non-ionic detergent (R-77) and 2 gpl sodium carbonate for 30 minutes at 80 °C temperature. The fabrics were then washed thoroughly in running water, neutralized, washed again in running water, and finally dried under shade. The pre-treatment process was carried out in the LG Direct Drive washing machine. The pH of the fabrics was checked to neutral before further processing.

Application of Zycrobial on fabric by padding technique: Application of *Zycrobial* on fabric was done by padding technique. In pad application, the fabric immersed in liquor contain the required amount of antimicrobial agent (*Zycrobial*- 10 gpl) and passes through the padding mangle at 2.5 kg/cm^2 pressure using laboratory two bowl padding mangle. The fabric was subsequently dried and cured at room temperature.

Washing durability test

The durability of the *zycrobial* treatment was evaluated by BS EN 26330:1994 method using the domestic washing process. The specimen was washed in an automatic domestic washing machine by using ECE detergent. The process was repeated 20 times using the same procedure of washing. After 10 and 20 washes the samples were again tested for their efficacy against bacterium using AATCC TM 100.

Evaluation of antibacterial property by AATCC TM-100 quantitative method

Table 2: List of the pathogens with their morphology and possible infections to be tested for uniform.

Organisms	Morphology	Environment	Infections
Escherichia coli ATCC 35218	G-ve, Rods	Hospital, Water, Milk	HAI, Skin, Soft skin, UTI, ENTRIC
Staphylococcus aureus ATCC 6538	G+ve, cluster of cocci	Milk, Food, Hospital	Atopic dermatitis, Impetigo, Scalded skin syndrome
Klebsiella pneumoniae ATCC 4352	G-ve, Rods	Hospital	HAI, Pneumoniae
Bacillus cereus ATCC 13061	G+ve, Rods	Water, Food	Necrotizing fasciitis, Food poisoning

Antibacterial activity of the samples was evaluated by using AATCC TM 100 method [21], four bacteria namely Bacillus cereus (ATCC 11778), Escherichia coli (ATCC 35218), Klebsiella pneumonia (ATCC 4352), and Staphylococcus aureus (ATCC 6538) as test bacterium. The size was set 1-2 × 10^{5}cfu/ml and sample of the fabric for each bacterium was used such that it would absorb 1 ml of the bacterium. A plate count spread plate technique was utilized for this bacterium efficiency test. The incubation period was 37 °C for 24 hrs. List and details of selected pathogens are given in Table 2.

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Results and Discussion

Antimicrobial efficacy of treatment fabric and after repeated washing as per quantitative test- AATCC TM 100

In this study P/V, P/C and 100% Cotton fabric were treated with antibacterial chemical and four types of bacteria namely *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae* and *Bacillus cereus* were selected for testing antimicrobial efficiency. The antibacterial activity on P/V fabric is mentioned in Table 3. It can be observed from the Table 3 that excellent antibacterial activity against *E. Coli, S. Aureus and B. cereus* with >99% activity and good activity (>96%) against K. Pneumoniae is obtained on treated P/V fabric. Antimicrobial activity after 10 and 20 washes against two common bacteria E. Coli and S. Aureus is found to be high. The efficacy on P/V fabric against K. Pneumoniae and B. cereus after 10 and 20 washes is comparatively lower than other two microbes, however overall bacterial reduction is good (> 65%). Table 4 shows activity on P/C treated fabric against the four bacteria. Treated fabric shows very high level of antibacterial activity, killing all the bacterial colonies for *E. Coli* and *S. Aureus. K. Pneumonia* showed comparatively lower reduction (>94%) than other three bacteria. P/C fabric after 10 washes for all bacteria has > 70% efficacy and after 20 washes >60% efficacy. Table 5 shows activity on 100% cotton fabric against four bacteria. Excellent antibacterial activity obtained on cotton from 95% to complete elimination of bacteria. 10 times washed cotton fabric showed > 76% activity and > 60% activity after 20 washes. It is evident from the results that *Zycrobial* treatment showed more than 60% bacterial reduction on all types of fabrics against all four bacteria. Also K. Pneumonia showed higher resistance against the treatment.

Table 3: Quantitative evaluation of the antibacterial activity of treated P/V fabric by AATCC 100 method.

Bacteria	Treated	10 Wash	20 Wash
Escherichia coli	99.93	99.78	99.78
Staphylococcus aureus	99.28	95.24	75.68
Klebsiella pneumonia	96.25	78.24	65.14
Bacillus cereus	100	75.69	68.22

Table 4: Quantitative evaluation of the antibacterial activity of treated P/C fabric by AATCC 100 method.

Bacteria	Treated	10 Wash	20 Wash
Escherichia coli	100	73.12	65.18
Staphylococcus aureus	100	76.75	62.15
Klebsiella pneumonia	94.33	71.11	60.89
Bacillus cereus	98.97	78.62	66.18

In (Figures 1-4), the antibacterial activity of the Alkoxy alkylsilyl dimethyl octadecyl ammonium chloride *(zycrobial)* treated P/V, P/C, and Cotton against four different bacterial species is shown.

Zycrobial treatment at a very low dosage i.e., 10 gpl showed high retentivity after 20 washing cycles as evident from the antibacterial results. However, it is worth noting that the treatment curing was done at room temperature to simulate the existing drying-curing process at home or at a laundry. Alkoxy alkylsilyl quaternary ammonium chloride compounds are reactive molecule and forms bond with fabric after proper curing. As room temperature curing is a slow process, so the curing takes time. The reason for reduction of antibacterial activity after 20 washes can be attributed to lower overall curing of molecule on the fabric.

Textiles made from natural fibres are generally more susceptible to bio-deterioration than are synthetic (man-made) fibres [22,23] This is because their porous hydrophilic structure retains water, oxygen, and nutrients, providing perfect environments for bacterial growth. Products such as starch, protein derivatives, fats, and oils used in the finishing textiles can also promote microbial growth. Micro-organisms may attack the entire substrate, that is the textiles fibres, or may attack only one

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component of the substrate or grow on dirt that has accumulated on the surface of a product. It can also be observed from the results that cotton and P/C fabric showed over all good bacterial reduction, however the bacterial reduction on P/V (synthetic/ regenerated cellulose) overall higher than other types of fabric.

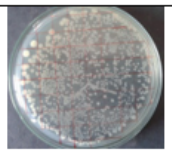
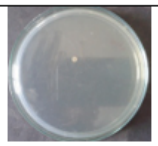
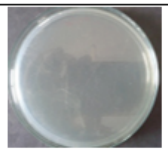
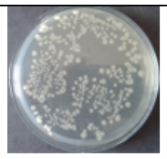
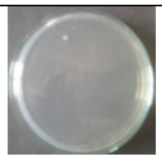
Fabric	Untreated sample plate ('0 hr' Contact time)	*Zycrobial* Treated sample plate ('24 hrs' Contact time)
P/V Fabric	 1.36×10^{5} cfu/ml	 1×10^{2}cfu/ml
P/ C Fabric	 1.6×10^{5} cfu/ml	 0cfu/ml
100% Cotton Fabric	 1.3×10^{5} cfu/ml	 1×10^{2} cfu/ml

Figure 1: Antimicrobial activity of untreated and treated P/V, P/C and xotton fabrics against *E. coli* using AATCC 100 method. *Escherichia coli* (-Ve) (ATCC 8739)

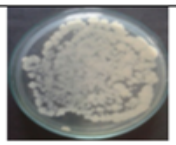
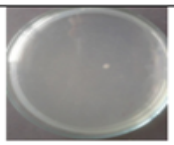
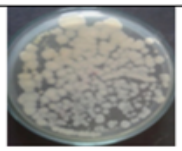
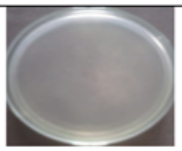
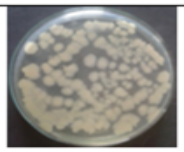
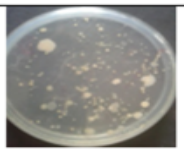
Fabric	Untreated sample plate ('0 hr' Contact time)	*Zycrobial* Treated sample plate ('24 hrs' Contact time)
P/V Fabric	 1.38×10^{5} cfu/ml	 1×10^{3}cfu/ml
P/ C Fabric	 1.25×10^{5} cfu/ml	 0cfu/ml
100% Cotton Fabric	 1.2×10^{5} cfu/ml	 7×10^{3}cfu/ml

Figure 2: Antimicrobial activity of untreated and treated P/V, P/C and cotton fabrics against *S. aureus* using AATCC TM 100. *Staphylococcus aureus* (+Ve) (ATCC 6538)

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Table 5: Quantitative evaluation of the antibacterial activity of treated 100% cotton fabric by AATCC 100 method.

Bacteria	Treated	10 Wash	20 Wash
Escherichia coli	99.93	76.12	62.53
Staphylococcus aureus	95.17	79.73	65.2
Klebsiella pneumonia	100	78	60.16
Bacillus cereus	100	83.22	68.56

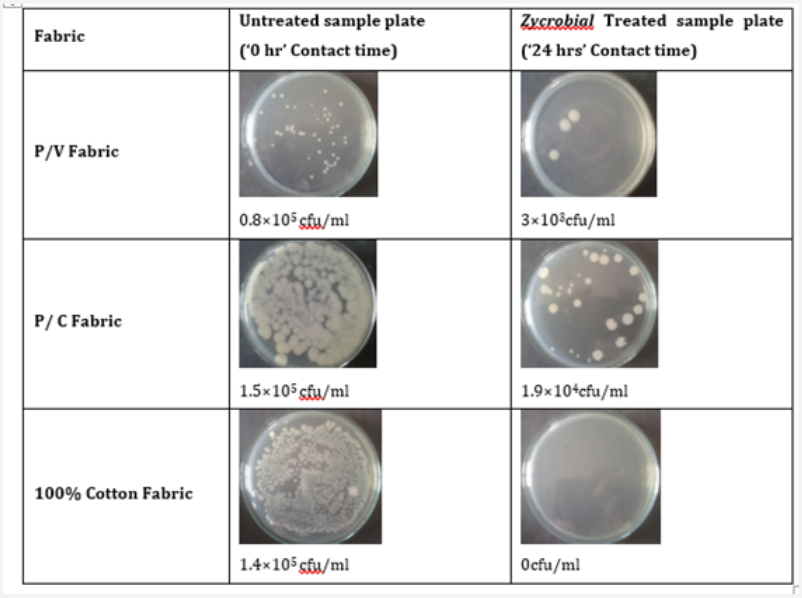

Figure 3: Antimicrobial activity of untreated and treated P/V, P/C and cotton fabrics against *K.pneumoniausing* AATCC TM 100. *Klebsiella pneumonia* (-Ve) (ATCC 10031)

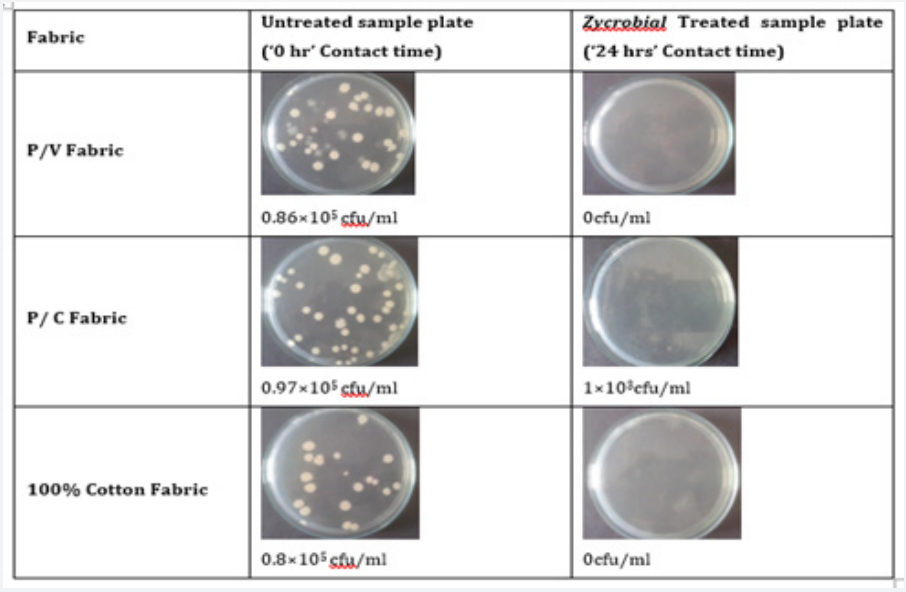

Figure 4: Antimicrobial activity of untreated and treated P/V, P/C and Cotton fabrics against *B. cereus* using AATCC TM 100. *Bacillus cereus* (+Ve) (ATCC 11778)

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Conclusion

Alkoxy alkylsilyl dimethyl octadecyl ammonium chloride *(Zycrobial)*, a quaternary ammonium chloride compound can be applied by an economical pad-batch technique on cotton, polyester/cotton, and polyester/viscose blend fabric. The treated P/V, P/C and Cotton fabrics showed around 95-100% efficiency against E. coli, S. aureus, K. Pneumonia and *B. Cereus* bacterium and good bacterial reduction (more than 60%) even after 20 washes. It suggests that the Alkoxy alkylsilyl dimethyl octadecyl ammonium chloride treated textiles may be used routinely to minimize transpersonal contamination in the environment. The durability of antimicrobial treatment evaluated by standard laundering illustrates the treatment provides protection up to 20 washes against all the four bacteria. A wide range of antimicrobial agents is now available for the benefit of the textile consumer. Treatment should also be given to uniforms, tents, defense textiles and technical textiles, which do not meet the human body, but this finish can be given to increase the life of the product.

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References

1. D Gopalakrishnan, RK Ashwini (2013) Antimicrobial finishes.
2. K Schatz (2001) All-round answer to problem microbes. International Dyer :17-19.
3. Ian Holme (2002) Antimicrobials impart durable freshness. International Dyer 187(12): 9-11.
4. BH Patel, MG Tandel (2005) Antimicrobial finish to cotton fabric by natural extracts. Man-Made Textiles in India p. 473.
5. E. Menezes (2002) Antimicrobial Finishing for Speciality Textiles. International Dyer 187(12): 13-16.
6. BH Patel, MG Tandel (2005) Antimicrobial Finishing for Speciality Textiles. International Dyer p. 31.
7. BH Patel, KU Desai (2014) Corporate uniform fabrics with antimicrobial edge preparation and evaluation methodology. International Dyer 2: 33-38.
8. Y Gao, R Cranston (2008) Recent advances in antimicrobial treatments of textiles. Textile Research Journal 78: 60.
9. Y Yang (2000) Durability of some antibacterial treatments to repeated home launderings. Textile Chemist and Colorist and American Dyestuff Reporter 32(4): 44-49.
10. W Huang, KK Leonas (2000) Evaluating a one-bath process for imparting antimicrobial activity and repellence to non-woven surgical gown fabrics. Textile Research Journal 70(9): 774-782.
11. H Seong, J Kim, S Ko (1999) Preparing Chito-oligosaccharides as antimicrobial agents for cotton. Textile Research Journal 69(7): 483-488.
12. https://www.diffen.com/difference/Gram-negative_Bacteria_vs_Gram-positive_Bacteria.
13. https://en.wikipedia.org/wiki/Gram-positive_bacteria.
14. Francois NR Renaud, Jeanne Dore, H Jean Freney (2006) Evaluation of antimicrobial properties of a textile product with antimicrobial finish in a hospital environment. Journal of Industrial Textile 36(1): 89.
15. Alireza A, Sanam M (2012) Microbial profile of air contamination in hospital wards. Iranian Journal of Pathology 7(3): 177-182.
16. http://advin.org/en/general-documentation/major-nosocomial -infections -and-their-causes.
17. http://infectiousdiseases.about.com/od/g/a/milkborne.
18. http://archive.bio.ed.ac.uk/jdeacon/microbes/airborne.htm.
19. WD Schindler, PJ Hauser (2004) Chemical finishing of textiles, Woodhead Publishing in Textiles, Sawston, United Kingdom.
20. KU Desai, BH Patel (2015) Bio-Burden Test: New Approach to Evaluate Efficacy of Corporate Uniform against Human Pathogenic Bacterium. Journal of Current Pharma Research 5(4): 1647-1653.
21. (2008) AATCC Test method 100 and 147-Antibacterial Test, AATCC Technical manual, p.83.
22. BH Patel, KJ Patel, JA Naik, AM Bhavsar (2004) Dyeing and antimicrobial finishing of cotton. Man-made Textiles in India 48 (11): 426.
23. Boryo DEA (2013) The Effect of Microbes on Textile Material: A Review on the Way-Out So Far. The International Journal of Engineering and Science 2(8): 9-13.

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