JOURNAL OF PURE AND APPLIED MICROBIOLOGY, October 2010. Vol. **4**(2), p. 513-516

Efficacy of Antimicrobial Finish on Cotton Fabrics

Suvamoy Datta[1,2]*, Md. Abbas Uddin[3] and Amrita Bandyopadhyay[4]

[1]Department of Microbiology, Primeasia University, HBR Tower, 9 Banani, Dhaka - 1213, Bangladesh.
[2]The Hormel Institute, University of Minnesota, 801 16th Ave, NE, Austin, MN 55912, USA.
[3]Department of Textile Engineering, Primeasia University, HBR Tower,9 Banani, Dhaka-1213, Bangladesh.
[4]DOEACC Centre, Jadavpur University Campus, Kolkata - 700 032, India.

(Received: 08 January 2010; accepted: 20 February 2010)

The growth of microbes on textiles during use and storage negatively affects the wearer as well as the textile itself. The detrimental effects can be controlled by durable antimicrobial finishing of the textile using broad-spectrum biocides or by incorporating the biocide into synthetic fibers during extrusion. Antimicrobial finish was incorporated into woven and knitted fabrics using ReputexTM 20, which is an antimicrobial agent. The objective was to produce antimicrobial fabrics and study the effectiveness of the antimicrobial finish. Among the various techniques available for the application of antimicrobial finish, padding method was used. A roll of knit/woven fabric was passed through a water bath containing a suitable concentration of ReputexTM 20. The fabric was then passed between two rollers to squeeze out excess liquid and was dried. Then the antimicrobial potency was quantitatively determined. Knit fabric was found to be better than woven fabrics in terms of antimicrobial effectiveness. It was also observed that pH 7 is better for antimicrobial finish for both knit and woven fabrics.

Key words: Antimicrobial finish, fabric, effectiveness.

Clothing can act as carriers for microorganisms such as pathogenic or odour-generating bacteria or moulds by offering an ideal environment for microbial growth, providing oxygen, water and warmth, as well as nutrients from spillages and body exudates[1]. The growth of microbes on textiles during use and storage negatively affects the wearer as well as the textile itself. The detrimental effects can be controlled by durable antimicrobial finishing of the textile using broad-spectrum biocides[2].

Cotton, one of the most important natural textiles, is widely used in clothing fields for its excellent properties such as regeneration, bio-degradation, softness, affinity to skin and hygroscopic property. However, cotton is more susceptible to attack by bacteria than synthetic fibers due to its large surface area and its ability to retain moisture, and thereby providing a perfect environment for bacteria growth[2-3].

So, there has been increasing interest in building antibacterial properties into textiles. Antibacterial finishes are also highly desirable for

* To whom all correspondence should be addressed.
Tel.: +001-507-437-9646; Fax: +001-507-437-9606
E-mail: sdatta@hi.umn.edu

textiles in the medical field as textile materials used in hospitals and hotels are liable to promote cross-infection and promote disease; in fact hygiene problems with hospital textiles can interfere with the recovery of patients[1]. Some of the most recent developments in antimicrobial treatments of textiles are the use of various active agents such as silver, quaternary ammonium salts, polyhexamethylene biguanide, triclosan, chitosan, dyes and regenerable *N*-halamine compounds and peroxyacids[2].

The main objective of our research was to produce antimicrobial cotton fabrics and to find out the efficiency of antimicrobial finishes on the fabrics.

MATERIAL AND METHODS

Samples of knitted and woven fabrics were collected from various textile mills situated in Dhaka, Gazipur and Narayanganj. 5g each of the different fabric samples were prepared for incorporating antimicrobial finish. ReputexTM20 was used as a finishing agent.

ReputexTM 20 is based on the molecule poly hexamethylene biguanide, or PHMB. ReputexTM 20 is a high molecular weight grade of PHMB developed specially for textile & non woven applications. It provides a durable treatment for cotton, cotton blends (cotton content >35%) and viscose which controls the population of bacteria on the fiber, and reduces the effects of bacterial action such as odour generation, degradation of the fabric, and transfer of organisms[4].

The antimicrobial agents can be applied to the textile substrates by exhaust, pad-dry-cure, coating, spray and foam techniques. The substances can also be applied by directly adding into the fibre spinning dope. It is claimed that the commercial agents can be applied online during the dyeing and finishing operations[4].

Padding method was used by us for antimicrobial finish on knitted and woven fabrics. A roll of knit/woven fabric was passed through a water bath containing a suitable concentration of ReputexTM 20. The fabric was then passed between two rollers to squeeze out excess liquid and was dried. Then the antimicrobial effectiveness of the finish was tested.

A number of test methods have been developed to determine the efficacy of

Table 1. Antimicrobial effectiveness of ReputexTM 20 treated woven and knit fabrics against *Staphylococcus aureus* at different pH

Sample	Untreated (B)	Treated (A)	R (reduction %)
1. Woven (pH 6)	4.0×10^5	3.0×10^5	25.0
2. Woven (pH 7)	4.0×10^5	1.5×10^5	62.5
3. Woven (8.5)	2.8×10^5	1.12×10^5	60.0
4. Knit (pH 6)	4.0×10^5	1.0×10^5	75.0
5. Knit (pH 7)	8.0×10^5	1.0×10^5	87.5
6. Knit (pH 8.5)	2.1×10^5	3.0×10^5	85.71

Table 2. Antimicrobial effectiveness of ReputexTM 20 treated woven and knit fabrics against *Klebsiella pneumoniae* at different pH

Sample	Untreated (B)	Treated (A)	R (reduction %)
1. Woven (pH 6)	4.2×10^5	3.4×10^5	19.04
2. Woven (pH 7)	4.0×10^5	2.2×10^5	45.00
3. Woven (8.5)	4.4×10^5	1.6×10^5	63.63
4. Knit (pH 6)	7.0×10^5	1.8×10^5	74.28
5. Knit (pH 7)	9.0×10^5	2.0×10^5	77.78
6. Knit (pH 8.5)	8.2×10^5	2.2×10^5	73.17

antimicrobial textiles[5-7]. These methods generally fall into two categories: the agar diffusion test and suspension test.

We used ATCC-100 [8] test procedure, which is a suspension test[2], to define the effectiveness of the antimicrobial agent on cotton fabrics. This test method provides a quantitative procedure for the evaluation of the degree of antibacterial activity. Assessment of antibacterial activity finishes on textile material is determined by the degree of antibacterial activity intended in the use of such materials. If only bacteriostatic activity (inhibition of multiplication) is intended, a qualitative procedure which clearly demonstrates antibacterial activity as contrasted with lack of such activity by an untreated specimen may be acceptable. However, if bactericidal activity is intended or implied, quantitative evaluation is necessary. Quantitative evaluation also provides a clearer picture for possible uses of such treated textile materials.

In order to test the potency of antimicrobial activity of various finished fabrics, circular swatches 4.8 $\pm$ 0.1cm (1.9 $\pm$ 0.03 inches) in diameter, were cut from the test fabrics treated for antibacterial finish. The swatches were stacked in a 250 ml wide mouthed glass jar with screw cap. The number of swatches to be used is dependent on the fiber type and fabric construction. Similarly swatches of the same fiber type and fabric construction but containing no antibacterial finish, were taken as control test samples. The standard microbial samples were prepared in normal saline (0.9% NaCl) and diluted for the microbial counts. The swatches were placed separately in sterile petridishes and inoculated ensuring uniform distribution of the inoculum. These swatches were transferred aseptically to the jar and covered tightly to prevent evaporation. The procedure in AATCC TM100 was followed. Finally, after incubation, bacterial counts were reported and percentage (%) of antimicrobial potency of natural dyes against Gram positive and Gram negative bacteria were determined, by the formula, R= 100 X (B-A)/ B[8]. In the present study, *Staphylococcus aureus* and *Klebsiella pneumoniae* are used as test organisms. Plate count agar was used for Gram positive bacteria and Mac-Conkey agar media was used for Gram negative bacteria.

RESULTS

Antimicrobial tests of the finished knitted and woven fabrics (finished at different pH values) were done to determine the optimum pH for obtaining proper antimicrobial finish. From Table 1, it is evident that fabric finishing with ReputexTM 20 was most effective for *S. aureus* at neutral pH for both woven and knitted fabrics. Table 2 shows that fabric finishing with ReputexTM 20 was most effective for *Klebsiella pneumoniae* at neutral pH for knitted fabrics only.

Owing to its cationic nature, PHMB attachment to cotton is believed to be through ionic as well as hydrogen bonding. The carboxyl groups on cotton fabrics that have originated from chemical finishing are involved in some of these interactions. Dyeing of cotton fabrics with reactive dyes, which introduces additional anionic sulphonic groups in the fabric, further increases the uptake of PHMB, but the strong ionic bonding may decrease the release of free PHMB and antimicrobial efficiency. So, for a cationic biocide like ReputexTM 20, pH 7 might be a balanced condition for very good fabric binding and efficient antimicrobial activity.

Better antimicrobial effectiveness was obtained with ReputexTM 20 for knit fabric than woven fabrics. This can be attributed to the better uptake of the chemical biocide by the knit fabrics.

DISCUSSION

Being a potent and broad spectrum bactericidal agent with low toxicity (MIC = 0.5–10 ppm, Arch technical information), it has been successfully used as a disinfectant in the food industry and in the sanitization of swimming pools[9] and is being explored as a biocide in mouthwasher[10] and wound dressings[11]. PHMB impairs the integrity of the cell membrane in its action, and its activity increases on a weight basis with increasing levels of polymerization[9]. To date, bacterial resistance to PHMB has rarely been observed although resistance to the bisbiguanide chlorhexidine is well known[12,13].

In order to obtain the greatest benefit, an ideal antimicrobial treatment of textiles should satisfy a number of requirements[14,15]. Firstly, it should be effective against a broad spectrum of bacterial and fungal species, but at the same time exhibit low toxicity to consumers, e.g. not cause toxicity, allergy or irritation to the user. Antimicrobial-treated textiles have to meet standards in compatibility tests (cytotoxicity, irritation and sensitization) before marketing. Secondly, the finishing should be durable to laundering, dry cleaning and hot pressing. This is the greatest challenge as textile products are subjected to repeated washing during their life. Thirdly, the finishing should not negatively affect the quality (e.g. physical strength and handle) or appearance of the textile. Finally, the finishing should preferably be compatible with textile chemical processes such as dyeing, be cost effective and not produce harmful substances to the manufacturer and the environment. One further consideration is that the antimicrobial finishing of textiles should not kill the resident flora of nonpathogenic bacteria on the skin of the wearer, which are important to the health of the skin as they lower skin surface pH and produce antibiotics to create an unfavorable environment for the growth of pathogenic bacteria[16].

Our result showed that better antimicrobial effectiveness is obtained with ReputexTM 20 for knit fabric than woven fabrics. We also observed that pH range of 7 to 8.5 is better for antimicrobial finish for both knit & woven fabrics with ReputexTM 20. So, chemicals (like ReputexTM 20) which satisfy the above mentioned requirements can well be employed in industries for the desired antimicrobial property in fabrics.

REFERENCES

1. Gupta, D., Khare, S.K., Laha, A. Antimicrobial properties of Natural dyes against Gram-negative bacteria. *Color Technol.*, 2004; **120**: 167-171.
2. Yuan, G., Robin, C. Recent Advances in Antimicrobial Treatments of Textiles. *Text. Res. J.*, 2008; **78**(1): 60-72.
3. Zhang, F., Zhang, D. , Chen, Y. *et al.* The antimicrobial activity of the cotton fabric grafted with an amino-terminated hyperbranched polymer. *Cellulose.* 2009; **16:** 281-288.
4. Ramachandran, T., Rajendrakumar, K., Rajendran, R. Antimicrobial Agents for Cotton. *Text. Res. J.*, 2004; **84**: 42-47.
5. Joiner, B.G.: Determining Antimicrobial Efficacy and Biocompatibility of Treated Articles using Standard Test Methods. In: *Bioactive Fibres and Polymers* (Edwards JV, Vigo TL eds). Washington DC: American Chemical Society, 2001; 201-217.
6. Hofer, D.: Antimicrobial Textiles—Evaluation of their Effectiveness and Safety. In: Biofunctional Textiles and the Skin (Hipler UC, Elsner, P. eds) Karger Basel, 2006; 42-50.
7. Analysis and Assessment of Current Protocols to Develop Harmonised Test Methods and Relevant Performance Standards for the Efficacy Testing of Treated Articles/Treated Materials, http://www.olis.oecd.org/olis/2007doc.nsf/43bb6130e5e86e5fc12569fa005d004c/0b18528d8e9cec03c1257288005b024c/$FILE/
8. AATCC Technical Manuals Quantitative test. TM 100-2004: 2006; 150.
9. McDonnell, G., Russell, A.D. Antiseptics and Disinfectants: Activity, Action, and Resistance, *Clin. Microbiol. Rev*., 1999; **12**: 147–179.
10. Rosin, M., Welk, A., Bernhardt, O. *et al.* Effect of a Polyhexamethylene Biguanide Mouthrinse on Bacterial Counts and Plaque, *J.Clin. Periodontol*., 2001; **28**: 1121-1126.
11. Cazzaniga, A., Serralta, V., Davis, S. *et al*. The Effect of an Antimicrobial Gauze Dressing Impregnated with 0.2-percent Polyhexamethylene Biguanide as a Barrier to Prevent *Pseudomonas aeruginosa* Wound Invasion, *Wound-compend. Clin. Res. Prac*.,2002; **14**: 169-176.
12. Russell, A.D. Introduction of Biocides into Clinical Practice and the Impact on Antibiotic Resistance, *J. Appl. Microbiol.,* 2002; **92**: 121S -135S.
13. Russell, A.D. Bacterial Adaptation and Resistance to Antiseptics, Disinfectants and Preservatives is Not a New Phenomenon. *J. Hosp. Infect.*, 2004; **57**: 97-104.
14. Purwar, R., Joshi, M. Recent Developments in Antimicrobial Finishing of Textiles - A Review, *AATCC Review*, 2004; **4**: 22-26.
15. Williams, J.F., HaloSource, V., Cho, U. Antimicrobial Functions for Synthetic Fibers: Recent Developments, *AATCC Review*, 2005; **5**: 17-21.
16. Elsner, P. Antimicrobials and the Skin Physiological and Pathological Flora. In: *Biofunctional Textiles and the Skin* (Hipler UC, Elsner P eds). Karger, Basel, 2006; 35- 41.