(REFEREED RESEARCH)

SIMULTANEOUS ANTIMICROBIAL, WATER AND BLOOD REPELLENT FINISHING OF DISPOSAL NONWOVENS USING CTAB AND FLUOROCHEMICAL

TEK KULLANIMLIK DOKUSUZ YÜZEYLERİN ANTİMİKROBİYAL, SU VE KAN İTİCİ BİTİM İŞLEMLERİNİN CTAB VE FLOROKİMYASAL KULLANARAK AYNI ANDA GERÇEKLEŞTİRİLMESİ

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ABSTRACT

In this research, Cetyl Trimethyl Ammonium Bromide (CTAB), as an antimicrobial agent, applied on polyester, polypropylene and viscose non-woven fabrics. Also, CTAB coapplied with a fluorochemical based water repellent agent namely FC1112. The antimicrobial, water and blood repellency of the treated samples were investigated. To reveal the antimicrobial properties of the treated samples, the zone of inhibition and reduction of bacteria were measured with S. aureus, E. coli and P. aeroginosa. The results showed a good antimicrobial property on different concentration of CTAB solutions (1%, 2%, 4% and 8%). Application of CTAB with concentration of (0.5%, 1% and 2%) on polyester, polypropylene and viscose nonwoven fabrics indicated a reasonable antimicrobial effect. Co-application of CTAB with fluorochemical on different samples also showed a good antimicrobial, water and blood repellency properties.

Key Words: Antimicrobial, Water repellent, Blood repellent, Nonwoven fabrics, CTAB

ÖZET

Bu çalışmada, CTAB (Cetyl Trimethyl Ammonium Bromide) bir antimikrobiyal aktif madde olarak polyester, poliamid ve viskoz dokusuz yüzey kumaşlara uygulanmıştır. Aynı zamanda CTAB, FC112 adı verilen su itici özellikteki bir florokimyasal ile birlikte de uygulanmıştır. İşleme tabi tutulan örneklerin antimikrobiyal, su ve kan iticilik özellikleri araştırılmıştır. İşleme tabi tutulan örneklerin antimikrobiyal özelliklerini açığa çıkarmak için, yüzeydeki bakterilerdeki azalma değerleri S. Aureus, E. Coli ve P. Aeroginosa ile ölçülmüştür. Sonuçlar, farklı konsantrasyondaki CTAB solüsyonlarının (%1, %2, %4 ve %8) iyi değerlerde antimikrobiyal özellik gösterdiğini ortaya koymuştur. %0,5, %1 ve %2 konsantrasyondaki CTAB uygulamalarının polyester, polipropilen ve viskoz dokusuz yüzey kumaşlarda kabul edilebilir antimikrobiyal etki gösterdiğini açığa çıkarmıştır. CTAB ve florokimyasalın birlikte kullanımı ile farklı örneklerde yapılan uygulamalar, iyi değerlerde antimikrobiyal, su ve kan itici nitelik göstermiştir.

Anahtar Kelimeler: Antimikrobiyal, Su itici, Kan itici, Dokusuz yüzey kumaşlar, CTAB.

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1. INTRODUCTION

Textile goods are excellent substrate for growing microorganisms. For the last fifty years, the prevention of microbial attack on textile materials has become increasingly important to consumers and textile producers (1). Clothing such as socks and underwear faced with odor from body perspiration. Currently there is also an interest in protecting health care workers from diseases that might be carried out by patients. Especially for surgical gowns, there is an increasing need to protect medical staff from infection by blood borne pathogens such as HIV and HBV. Gowns should be able to prevent stricke through or wetting out of the fabric, and so surgical gown materials should have not only antimicrobial properties but also blood barrier properties (2). In addition the textile used in hotels, transportation and biological institution needs antimicrobial textiles (3).

Nowadays, nonwoven fabrics are the most commonly used textiles for surgical gowns, patient drapes, laboratory coats, coveralls, and other kinds of protective clothing (4). Polyethylene terephethalate is a preferred textile fiber in many durable applications of nonwoven for its ease of use and compatibility with other fibers.

Although Polyester has excellent mechanical strength and good stability but end use capacity is limited due to difficult to do functional finishing because of lack of polar groups on the surface and poor wet ability (5).

Fluorochemical mostly used as repellent agents in textile finishing, which satisfy the demand for high water repellency and also impart oil and soil repellency to textiles (6).

Different antimicrobial agents have been applied to obtain antimicrobial properties to textile (7-8). Among them, the quaternary ammonium salts of cationic surfactants are widely used in antimicrobial finishing of textile (9). Quaternary ammonium salts exhibit marked antimicrobial activity against a wide range of bacteria, fungi, and viruses (10-11). One way for disease transmission from one person to another is using clothes by different people in hospitals. Using of the disposable clothing products with antimicrobial finishing can provide a good protection against transmission of diseases for both the surgery team and patients.

In this study cetyl trimethyl ammonium bromide (CTAB) was used as an antimicrobial agents (Fig.1).

This agent have been frequently used in textile dyeing and finishing as either softener and leveling agents or as disinfectants or antimicrobial(10), but there is no report using CTAB as antimicrobial agents on different nonwoven fabrics. In this research, CTAB co applied with fluorochemical based water repellent agent to produce a nonwoven textile with different fire antimicrobial and water repellent and blood repellent.

2. EXPERIMENTAL

The polypropylene and polyester melt blown and raw and dyed (with direct dye) viscose nonwoven fabric chemical bonded with 80 g/cm^2, cetyl trimethyl ammonium bromide (CTAB) as an antimicrobial finish agent (Merck), citric acid (Merck) for adjusting the pH 5, and fluorochemical namely FC 1112 (Organic Kimia Co.) as a water and blood repellent agent were used.

To provide the antimicrobial finish, the samples were padded through baths of 0.5, 1 and 2% CTAB solution with wet pick up of 130%, dried at 80-85ºC for 3 min. and cured at 145-150ºC for 3 min. We also used both fluorochemical repellent agent and antimicrobial agent in one bath in different concentrations of CTAB 0.5, 1, 2%. The fluorochemical concentrations were 1, 2 and 3%.

The antimicrobial properties of samples were evaluated quantitively by measuring the reduction rate in the number of colonies (AATCC 100) and qualitatively by showing a clear zone of inhibition around the samples by disk diffusion method (11). In order to evaluate the antimicrobial properties of the samples, three common pathogen bacteria were used including: *Staphylococuse aureus* (gram positive), *Escherichia coli* (gram negative) and *Pseudomonas aeroginosa* (gram negative). The reduction rate of bacteria growth under agar plates was calculated by the following equation:

$R \% = (A-B)/A \times 100$

Where A is the number of bacteria colonies from an untreated fabric, and B is the number of bacteria colonies from the treated fabric.

Drop absorption was used to evaluate the water and blood repellency of the fabrics. To do this, droplet of water (distilled water) or blood (a synthetic blood) from 1cm of the fabric fall down on the fabric surface and the time of droplet disappearing was recorded.

3. RESULTS AND DISCUSSION

The antimicrobial and fluorochemical finishes used in this study were compatible in a single bath and applied to nonwoven fabrics to impart desirable properties.

The results of antimicrobial activities of polyester and polypropylene treated fabric with different bacteria were indicated in Tables 1-2. The inoculum was a nutrient broth culture containing 0.5×10^6, 1×10^6 and 1.5×10^6/mL colony-forming units (CFU) of the bacterium. It can be found that the CTAB can be act as a good antimicrobial agent on the nonwoven textile. 0.5% CTAB reduces the microbial growth to 90% that is sign of good antimicrobial agent. However, increasing of CTAB concentration to 1% on both polyester and polypropylene fabrics reasonably inhibited the growth of E. coli at pH=7 and S. aureus and P. aeroginosa at pH=5.5 (pH=5.5 is the pH of body skin). Higher concentrations of CTAB lead to higher microbial growth and better antimicrobial effect on both polyester and polypropylene fabrics. Overall, 1% CTAB can be enough to produce a good antimicrobial effect on the polyester and polypropylene nonwoven fabrics. The pH was not an effective parameter in this test in acidic and neutral media as the results were similar at pH 7 and pH 5.5.

Unfortunately, this test can not be used for viscose nonwoven fabric because of disturbing effect of adhesive used for fabric production as the production method was the chemical bonding. The chemical bonding materials come out form the fabric during the test and interfere with the results. As a result, the antimicrobial effects cannot be established on this type of fabric with CTAB.

The zone of inhibition also observed for each sample. The results indicated in Table 3 as the sign (+) represented for the sample with formation of zone of inhibition and the sign (-) for the sample without formation of zone of inhibition. For untreated fabric there are no sign of inhibition for microbial growth. Therefore, these samples have not antimicrobial properties themselves and need to be protected against microbial attacks. The results show a clear zone of inhibition around the treated samples with different concentration of CTAB. It was indicated that an increase in CTAB concentration leads to an increase in the zone of inhibition reflected by enlargement of the zone on inhibition diameter.

It was also found that the effectiveness of the antimicrobial finish of CTAB can not be influenced by the level of the fluorochemical finish.

The results of water and blood drop absorption presented in Table 4.

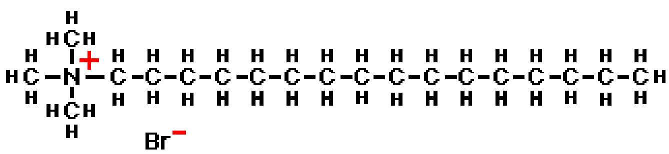

Figure 1. Chemical structure of cetyl trimethyl ammonium bromide (CTAB)

Table1. Antimicrobial activity of polyester and polypropylene fabrics treated with CTAB against different bacteria at various pH.

CTAB %	0.5	1	2
Reduction of *E. coli* at pH=7 on polypropylene	90	99.9999	99.9999
Reduction of *E. coli* at pH=7on polyester	90	99.9999	99.9999
Reduction of *S. aureus* at pH=5.5 on polypropylene	90	99.9999	99.9999
Reduction of *S. aureus* at pH=5.5 on polyester	90	99.9999	99.9999
Reduction of *P. aeroginosa* at pH=5.5on polypropylene	90	99	99.99
Reduction of *P. aeroginosa* at pH=5.5 on polyester	90	99	99.99

Table 2. Antimicrobial activity of polyester and polypropylene fabrics treated with mixture of CTAB and FC1112.

CTAB %	0.5	1	2
Reduction of *E. coli* at pH=7 on polypropylene	90	99	99.9999
Reduction of *E. coli* at pH=7 on polyester	90	99	99.9999
Reduction of *S. aureus* at pH=5.5 on polypropylene	90	90	99.9999
Reduction of *P. aeroginosa* at pH=5.5 on polypropylene	90	90	99.9999
Reduction of *S. aureus* at pH=5.5 on polyester	90	90	99.9999
Reduction of *P. aeroginosa* at pH=5.5 on polyester	90	90	99.9999

Table 3. Antimicrobial activities of polyester, polypropylene and white and dyed viscose fabrics treated with CTAB measured by zone of inhibition

Fabric	Materials%		Bacteria		
	CTAB	FC-1112	*P. aeroginosa*	*E. coli*	*S. aureus*
Polypropylene	0	0	-	-	-
Polyester	0	0	-	-	-
White Viscose	0	0	-	-	-
Dyed Viscose	0	0	-	-	-
Polypropylene	3	0	+	+	+
Polyester	3	0	+	+	+
White Viscose	3	0	+	+	+
Dyed Viscose	3	0	+	+	+
Polypropylene	2	0	+	+	+
Polyester	2	0	+	+	+
White Viscose	2	0	-	+	-
Dyed Viscose	2	0	-	+	-
Polypropylene	1	0	+	+	+
Polyester	1	0	+	+	+
White Viscose	1	0	-	+	-
Dyed Viscose	1	0	-	+	-
Polypropylene	0.5	0	-	-	-
Polyester	0.5	0	-	-	-
White Viscose	0.5	0	-	-	-
Dyed Viscose	0.5	0	-	-	-
Polypropylene	2	2	+	+	+
Polyester	2	2	+	+	+
White Viscose	2	2	+	+	+
Dyed Viscose	2	2	+	+	+

Table 4. Time of water and blood absorption for different treated samples with FC1112 and/or CTAB

Fabric	FC-1112%	Absorption time (seconds)	
		Water	Blood
Polypropylene	0	Less than 5	Less than 5
Polyester	0	Less than 5	Less than 5
White Viscose	0	Less than 5	Less than 5
Dyed Viscose	0	Less than 5	Less than 5
Polypropylene	1	More than 1800	More than 1800
Polyester	1	More than 1800	More than 1800
White Viscose	1	More than 1800	More than 1800
Dyed Viscose	1	More than 1800	More than 1800
Polypropylene	2	More than 1800	More than 3600
Polyester	2	More than 1800	More than 3600
White Viscose	2	More than 1800	More than 3600
Dyed Viscose	2	More than 1800	More than 3600
Polypropylene	3	More than 3600	More than 3600
Polyester	3	More than 3600	More than 3600
White Viscose	3	More than 3600	More than 3600
Dyed Viscose	3	More than 3600	More than 3600
Polypropylene	2+2%CTAB	More than 1200	More than 1200
Polyester	2+2%CTAB	More than 1200	More than 1200
White Viscose	2+2%CTAB	More than 1200	More than 1200
Dyed Viscose	2+2%CTAB	More than 1200	More than 1200

The results indicated that untreated fabrics are water and blood absorbable. This may causes problem for the user. To protect the used from microbial attacks fabrics should be non-absorable. Using 1% FC-1112 helps to produce a non-absorable fabric. Increasing FC-1112 improved the water repellency and blood repellency properties of the fabrics. The results showed that application of FC1112 on polyester, polypropylene and viscose fabrics has the similar influences. It means that protect different types of nonwovens from wetting by water and blood. The surface tension of water is 72 dyn/cm and for natural blood is around 52 dyn/cm. This means that water and blood can absorbed rapidly on the polyester and polypropylene fabric surface. Application of fluorochemical reduces the surface energy of the fabric and do not permit the water or blood droplet to adsorb and spread on the fabric surface. With application of sufficient concentration of fluorochemical on the fabric surfaces, it is possible to produce a fabric with water and blood repellent properties. Here, 2% fluorochemical was sufficient to produce a fabric with reasonable water repellent property. The results of co-application of fluorochemical with CTAB indicated that CTAB and fluorochemical have a good compatibility and could produce a fabric with multifunctional properties, as the fabric is antimicrobial as well as water and blood repellent. CTAB with cationic character in its structure cause a decrease in water and blood repellency of the co-applied fabrics. However, the co applied fabrics still show good water and blood repellency properties.

4. CONCLUSIONS

Antimicrobial nonwoven fabrics were prepared by directly incorporating of a qurternary ammonim salt namely, cethyl trimethyl ammonium bromide, on polyester and polypropylene nonwoven fabrics. An interesting observation is the clear zone of inhibition and excellent reduction of bacteria growth. It is apparent that the antimicrobial activity of CTAB is bactericidal in nature and not bacteriostatic. Treatment of different nonwoven fabrics with 1% CTAB produces antimicrobial effects. However the viscose nonwoven fabric produced by chemical bonding can not be tested with AATCC 100 method for antimicrobial evaluation. 2% CTAB is enough for producing an excellent protective polypropylene, polyester and viscose nonwoven fabric.

The antimicrobial and fluorochemical finishes used in this study were compatible in a single bath and could be applied to nonwoven fabrics to impart multifunctional effects. 2% fluorochemical with 2% CTAB can produce a fabric with antimicrobial and water and blood repellent properties.

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