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Interaction between Fluoro Emulsion and Silane Quaternary Ammonium Salt on Dual Antibacterial and Hydrophobic Fabric of Surgical Gown

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Abstract. Humans need more protection since environmental pollution becomes more serious problem. In many recent years, the appearance of many infectious diseases has generated the life-threatening and the tremendous challenges have given for medical scientists in diagnosis and treatment methods. Multifunctional protective costumes may be a good solution to protect efficiently human body from such risks. Among initiatives, dual antibacterial and water repellent fabric was able to be a great choice in designing the surgical gown in order to efficiently protect. This work provides usefully interesting information about the synergies among finishing agents on cotton fabric. Accordingly, the experimental results clarified the biocidal and hydrophobic mechanism at the same time under various conditions. In addition, the wearing comforts associated with heat tranfer and air exchange between body skin and fabric layers were concerned to increase the product performances.

Keywords: Antimicrobial, water repellence, fluoro emulsion, quaternary ammonium, comfort

1 Introduction

Multifunctional textiles have been widely developed during recent decades owing to innovative techniques such as nano-technology or plasma technology [1]. These studies not only diversify clothing products more but also please wearers or consumers. People are living in a bacterial world, in which these tiny creatures are sometime useful and sometime harmful as well [2,3]. Several reports were clarified that the growth of biomicrobes in a human structure might successful controlled through two methods: inhibition (barrier) and extermination (killer). In fact, there were a lot of natural as well as man-made compounds like triclosan, metallic salts, so on, which can apply to commercally produce antibacterial agents for many years. In recent, Messaoud et al., has showed that the antibacterial finishing of cotton-based fabrics might be achieved from quaternary ammonium-based composite particles [4]

In general, clothing products should have ability of the biocides the dangerous viruses to eliminate the risks of health, es-pecially illness, but they also maintain the convenience for wearers during their daily operations. For instance, a surgeon in hospital is frequently affected by patient's blood and fluid that he must deal with high infection rate, therefore, his gown in operating room needs to not only prevent blood fluid to permeate through cloth layers but also create the most comfort to him [5].

An attaching mechanism of the fluorocarbon agents onto textile surface is illustrated in Fig.1. Especially, fluorocarbon compound is well known as the best repellent

agent, meaning that both water and oil drops are efficiently easy to remove from fabric face (silicon agents or waxes only repel water, not oil) [6-8]

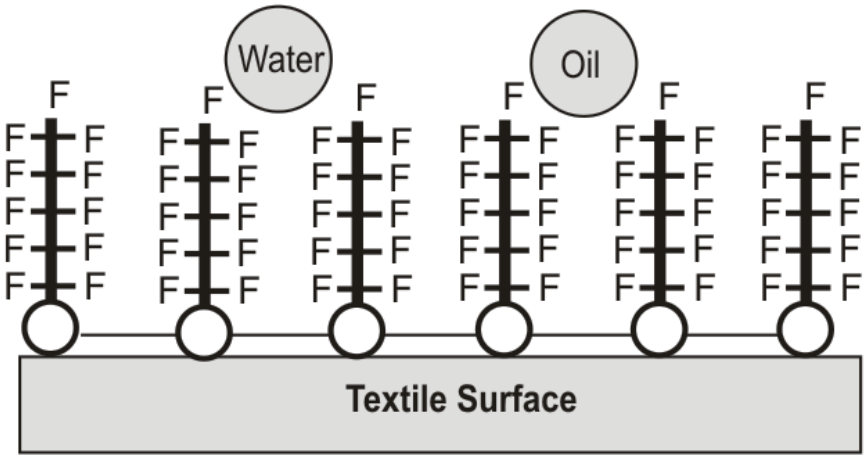


Fig 1. The bonding mechanism of fluorocarbon agent with textile fabrics explained to repel both water and oil drops from surface

Textile comfort is both physiological and psychological as a human feeling. In this study, the evaluation of thermal comfort was conducted through vapor permeability. Other points such as heat balance, heat loss will be discussed in next investigations.

2 Experiments

The antimicrobial emulsion (AEM-5772/5: 3-trimethylsilypropyldimethyloctadecyl ammonium chloride) and the water repellent agent (Nuva HPU: fluoro emulsion) on cotton fabric were purchased from Aegis and Clariant, respectively. Because of prevention of dilute solution into water repellent fabric, the antibacterial treatment process should be conducted first. The padding techniques with a stenter were applied for both antibacterial and water repellent processes under some various conditions. Pure cotton fabric were used for all tests due to its wide applications for human health protection. These samples were relaxed in room condition in order to ensure the uniformity of experimental measurements. The experimental results of microbiology, water absorbance, mechanics, comfort and drape were reported according to given standards. The durability of these treatments was determined via the washing cycles and the measurements and results were shown in term of diagram, such as the curve of washing times against agent residue, water resistance, air exchanging ability, so on. The photos were taken to reveal the fabric surface before and after treatments as well. Untreated, antibacterial, water repellent and dual antibacterial - water repellent cotton fabrics in the experiment named as S_O, S_A, S_W and S_{AW}, respectively.

Chemicals and microorganisms used for this experiments include bromophenol blue (BPB), Escherichia coli (E.Coli).

3 Results and Discussions

3.1 Biocidal ability of silane quaternary ammonium salt on cotton fabric based on quantitative decline of microbes

Antimicrobial activity of treated samples was quantified by counting the growth and reduction of microorganism (E.coli) in culture with microbiological measurements. All investigations reported that the amount of microbes on antimicrobial specimens slightly decreased with washing times in an hour of exposure or contact. It is known that the molecular bonds (i.e., the fastness of antimicrobial finish) of substrate (cotton fabric) and antimicrobial agent (ammonium salt) could be seriously affected under washing conditions. In particular, as shown in Table 1, most bacteria were eliminated after 24 contacting hours, meaning that the longer bacteria contacted antimicrobial fabric, the more finished textile fabric killed bacteria, even lower lost biocidal residue after more washing cycles.

Table 1: Antibacterial ability of treated samples after 1 and 24 hours of contacting with bacteria by microbiological testing method

Sample	Percentage of decreased bacteria	
	After 1 hour	After 24 hours
S_O	-	-
S_{A0}	55.47	97.91
S_{A5}	62.40	98.73
S_{A10}	74.13	99.17

3.2 Determinating antimicrobial activities by bromophenol blue (BPB)

Fig. 2 provides an evidence to explain why the content of bromophenol blue (BPB) is linearly proportional to the number of killed bacteria on fabric, corresponding to the residue of silane quaternary ammonium salt. The BPB measurements were quite quick, exact and totally consistent with the microbiological tests. However, such results determined only the content of antimicrobial agent but not biocidal ability of treated fabric because of dependence on contacting time, family of microbes and other additives.

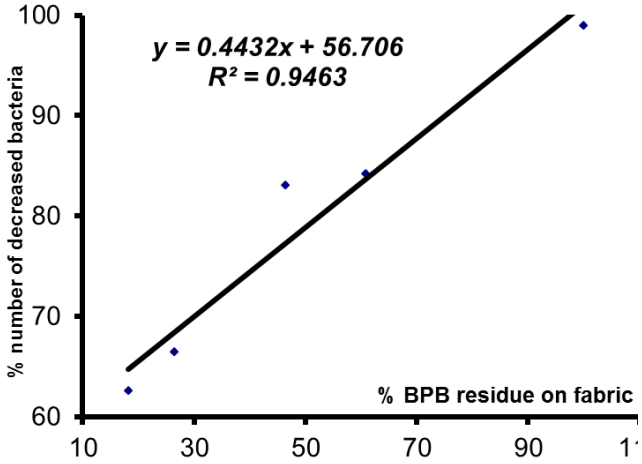


Fig.2. Linear graph of BPB content against amount of decreased microorganisms on fabric.

3.3 Investigation of biocidal ability on dual antimicrobial and water repellent treated cotton fabric

The main purpose of this work is to clarify the synergistic interaction among active substances of functional finishes on textile fabric through the efficiency of these treatments. Combinating antimicrobial treatment with water repellent treatment is very necessary for some textile products like surgical gown. Due to hydrophobicity of fluorocarbon compound on fabric, the antibacterial treatment should be treated before.

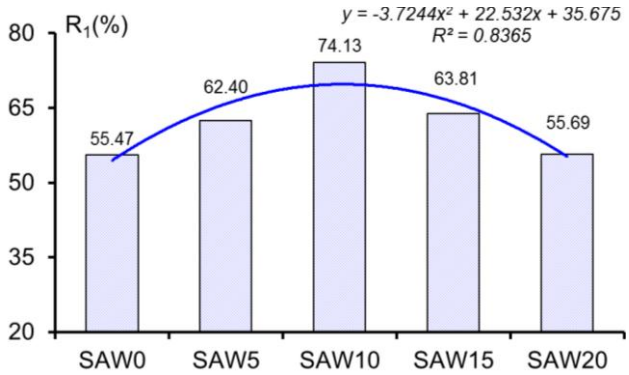


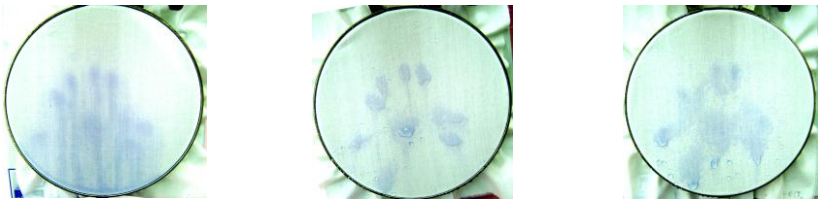
Fig.3 Biocidal ability of dual antimicrobial and hydrophobic treated fabric for 0, 5, 10, 15 and 20 of washing cycles

The results of biocidal measurement were indicated in Fig.3. Interestingly, biocidal ability of dual antimicrobial and hydrophobic material reached the highest value at 10 of washing cycles and decreased rapidly later. In fact, such phenomenon revealed that the productivity of water repellent finish reduced with washing times but that of antimicrobial finish raised since former one were covered earlier one. When the hydro-

phobic composition released from material surface, the microbes should be contacted with biocidal substance more, at which the washing cycle was up to 10. On the other hand, the number of microorganisms were killed the most as soon as they were adjacent to antibacterial agent. Nevertheless, at more than 10 times, the efficiency of both treatments declined rapidly because biocides and hydrophobicity were not able to retain enough to either attack or prevent microorganisms.

3.4 Water repellence of dual antimicrobial and water repellent treated fabric

In case of waterproof finish, water might easily push out of fabric surface, however, the moisture vapor could not transmit through the material. Obviously, the water repellent treatment with fluorocarbon still ensures the ventilation for fabric in which only water in drop form ,



(a) Untreated fabric (b) Water repellent fabric (c) Dual antimicrobial and water repellent fabric

Fig.4 Digital photos of water spraying tests for various types of fabric

3.5 Drape of antibacterial and water repellent treated and untreated fabrics

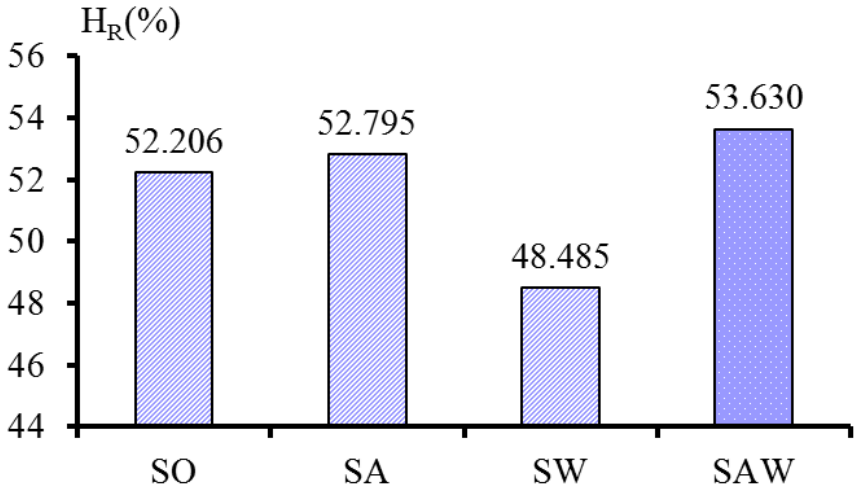


Fig.5. Drapes of untreated (SO), antimicrobial (SA), water repellent (SW) and dual antimicrobial – water repellent fabric (SAW)

The treated agents into fiber structure may basically reduce softness of fabric. Interestingly, the drape of dual functional material is quite higher than untreated or mono-functional samples as shown in Fig.5. Particularly, the drape of untreated sample was 52.206 % while that of antibacterial finish was even 48.485 % but that of dual finish was higher previous ones (i.e., 53.630%). It might explain that, after bonding to fabric, these chemicals, thus, might cause the loose yarn system due to the decrease in the coefficient of friction.

3.6 Change in air permeability as treating fabric by antimicrobial and water repellent agents

The obtained results in Table 2 show that vapor exchange of sample S_{AW} after 24 exposure hours occurs more than those of sample S_A and sample S_W. It can be explained in terms of the agent residue and fastness on treated fabrics.

Table 2: Results of antimicrobial and water repellent treatments based on change in weight after 24 testing hours

.Sample	Repeat	W_0 (g)	W_{24} (g)	V_{th} ($g/dm^2.24h$)
S_O	1	167.27	166.24	1.03
	2	165.57	164.55	1.01
	3	161.64	160.62	1.02
S_A	1	171.42	170.5	0.92
	2	161.2	160.26	0.94
	3	164.23	163.31	0.92
S_W	1	155.53	154.56	0.97
	2	141.59	140.63	0.96
	3	159.87	158.91	0.97
S_{AW}	1	161.57	160.59	0.98
	2	154.73	153.75	0.98
	3	163.97	162.99	0.98

However, the decrease of vapor permeability on dual functional treated fabric is very little as compared to untreated or mono-functional treated fabrics. On the other hand, this fabric allows air or vapor through its structure close to the untreated material, therefore human body should feel quite comfortable.

4 Conclusions

In this work, an interactive mechanism between antimicrobial and water repellent finishes was investigated through experimental results of microbiological, water absorbent and mechanical tests. Most significantly, synergistic interaction among two various added agents were found that the water repellency might slightly prevent the antimicrobial activity but it still ensured both requirements of finished fabric in hospital gowns. More detailed analysis of studying results will be published in the future work after implementing more investigations.

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