Science & Technology Development Journal – Engineering and Technology, 4(4):1277-1283

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Research Article

Application of triclosan in antibacterial finishing on 100% cotton fabric

Trinh Thi Kim Hue*, Bui Mai Huong

ABSTRACT

The demand for antibacterial fabric has been recently increasing in the medical textiles. The fibers used in textile products, especially those made from natural fibers with a large surface area and good moisture-retention capacity, provide a favorable condition for microbial growth. They are present almost everywhere and multiply rapidly, depending on moisture, nutrients, and the environment in which they live. The growth of microorganisms on textile products has caused a series of undesirable effects, not only on the product but also on the user of the products. Cotton fabric is easy to wrinkle. When exposed to a humid environment, it is susceptible to damage caused by microorganisms. Therefore, antibacterial treatment for Cotton fabric 100% is a important requirement in the textiles and garments depending on the intended use and is a prerequisite for fabric products in the medical field. Many antibacterial agents for textiles are already known such as organo-metallics, phenols, quaternary ammonium salts. Triclosan is a popular antibacterial chemical. Triclosan is present everywhere in life from consumer products such as toothpaste, soap, detergents, toys, household appliances to cosmetics. Especially Triclosan is an antibacterial agent used quite a lot in the textile industry. Triclosan with chlorinated phenol, a synthetic chemical, is common and potential antibacterial agent. In this study, The technical parameters were investigated include Triclosan concentration, dipping time, drying temperature, citric acid concentration to evaluate the effects of treated parameters on the antimicrobial efficiencies of the 100% cotton fabrics. The results show that cotton fabrics after finishing treatment with Triclosan and applying citric acid (CA) as important bonding chemical have good antibacterial ability and also have improved durable antibacterial properties after 5 launderings. The antibacterial properties of treated cotton fabrics was evaluated based on ASTM E2149-01 standard, the experiment was done with E.Coli ATCC 25922 and S. Aureus ATCC 6538.

Key words: Antibacterial, finishing, cotton, fabric, triclosan

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History

- Received: 01-11-2021
- Accepted: 07-01-2022
- Published: 14-01-2022

DOI : 10.32508/stdjet.v4i4.930

INTRODUCTION

Recently, with the Covid-19 epidemic stage, the demand for antibacterial textiles has been increasing in the medical field. The large surface and the retaining moisture of textile structures are the cause of microorganisms' growth, which have also been having undesirable effects on the textile itself and the users. Therefore, antibacterial finished textile is a crucial matter to medical and hygienic applications. Finishing antibacterial needs to ensure the following requirements for the best quality final product: Choose an appropriate antibacterial method that is easy to apply and does not cause adverse effects on fabrics; When finishing antibacterial, it is necessary to pay attention to the properties of the fabric such as elasticity, thermal impact and mechanical impact on the product; They do not create harmful substances that affect users and the environment; chemical concentrations within safe ranges,; low cost and efficiency, comply with requirements, regulations, laws on hygiene and safety during operation [1,2].

Triclosan to be an antibacterial and antifungal agent. Triclosan is present everywhere in life from consumer products such as toothpaste, soap, detergents, toys, household appliances to cosmetics. Especially Triclosan is an antibacterial agent used quite a lot in the textile industry. Antimicrobial activity of Triclosan will attack both cell membranes and cytoplasm. However, when commercialized, Triclosan is used at low concentrations within the allowable range, antibacterial activity will take place by inhibiting the fatty acid production of bacteria [3,4]. Finishing antibacterial on fabrics has the main purposes: Protect product users to minimize exposure to pathogenic microorganisms and Protects products from damage in durability and color caused by microorganisms, in addition to minimizing unpleasant odors from mold [5,6].

Therefore, Purpose of this study is to develop an antibacterial textile finished with Triclosan on cotton fabric with medium cotton fabric weight and fine-

Cite this article : Hue T T K, Huong B M. **Application of triclosan in antibacterial finishing on 100% cotton fabric**. *Sci. Tech. Dev. J. – Engineering and Technology;* 4(4):1277-1283.

ness. Triclosan is a synthetic chemical and it is finishing treated on the cotton fabric by chemical finishing method using dip-pad-dry process [7,8]. This method is simple and easy to perform.The antibacterial finish in this method is achieved by soaking the fabric in a solvent solution containing the antibacterial agent for a suitable time, which is then pressed through the padder. Finally the fabric is then dried at a specific temperature and time [9,10].

The technological parameters include Triclosan concentration, dipping time, drying temperature, etc.... Besides, cotton fabrics were treated with Triclosan and then treated with citric acid (CA) as important chemical to improve durable antimicrobial ability after 5 launderings. The antimicrobial ability of finished fabrics was evalutated based on ASTM 2149-01 standard, the experiment was done with E. Coli ATCC 25922 and S. Aureus ATCC 6538. Totally, achieved data showed an antimicrobial ability conferred by the treatment.

MATERIALS AND METHODS

Materials

Triclosan(5-Chloro-2(2,4 dichlorophenoxy)phenol, >90% purity), ethanol (99,5%), citric acid (99,5%) were taken from Xilong Chemical company in China. The particular 100% cotton fabrics, woven farbics, specific weight 181g/m^2, warp yarn count 141 threads cm^{-1}, weft yarn count 58 threads cm^{-1}, cotton fabric were pretreated to remove impurities (provided by Viet Thang Company) were used. Sizes were cut with 12 cm $\times$ 12 cm.

There are two bacterial used in the experiment.

They are E. coli and S. aureus. These bacterial were taken from Center for Biotechnology in Ho Chi Minh City, Viet Nam.

Coating process

Triclosan (3 g/l, 5g/l, 10 g/l, 20g/l) was applied to cotton fabrics separately using liquor ratio 1:10 and pH 5-7 by a dipping-padding–drying procedure. The fabric was dipped in triclosan solution and kept for 15 min, then padded with the padding at a suitable force of 2.2 bar to make the evenly surface of triclosan on each of the material substrates. Finally the fabrics were heated at 80^{o}C in 5 minutes in a drying machine.

To study the effect of dipping time, drying temperature, acid citric on the finishing process, three time was chosen: 15 mins, 30 mins, 45 mins; dry temperature (60^{o}C, 80^{o}C, 100^{o}C); citric acid (1%, 2% owf, concentration on weight fabric).

Chemical composition analysis

The treated fabric was determined by FTIR method, Bruker machine, Germany.

Antimicrobial testing

Determination of antimicrobial ability on finished cotton before washing and after five washing cycles on two bacteria E.coli and S.aureus based on ASTM E2149–01. The reduced amount of bacteria determined the antibacterial effect in standard conditions (37 $\pm$ 1^{o}C, 24 h). Antibacterial treated fabric samples were shaken in jar for each type with the required dilution containing different two bacteria. The microbial content of the solution was assessed after shaking. The antibacterial ability of the fabric sample was evaluated through the ability to kill bacteria. The rate of reduction of bacteria (%) after 60 minutes was determined by counting the number of bacterial CFU on the petri dish.

The fastness of antimicrobial ability to laundering

The laundering process was performed based on AATCC Method 124-1996. The setting condition for washing was exactly 40^{o}C.

RESULTS AND DISCUSSION

Evaluate the antimicrobial activity of the material after finishing with different triclosan concentration

Ability against bacteria of the materials after finishing with different triclosan (3 g/l, 5 g/l, 10g/l, 20 g/l) was performed by popular process based on ASTM E2149-01, using two particular bacteria E.coli and S. aureus.

The results of the above different triclosan concentration investigation proved that the best antimicrobial activity to E.coli and S.aureus on finished fabric was 100%, respectively. The obtained data from Table 1 and Table 2 proved that the possibility to resist S. aureus and E. coli on Cotton fabric is very good, with antibacterial capacity of 100% with triclosan 5 g/l,10g/l and 20 g/l. At triclosan 3 g/l, the antibacterial capacity was 90.76% for gram positive and 91.3 % for gram negative bacteria. From the above results, to save materials, triclosan 5 g/l is the most suitable for finishing antimicrobial possibility on both bacteria.

Investigate the effect of dipping time and drying temperature to antimicrobial possibility after finishing

The achieved data from Figure 1 proved that, after dipping time is 30 mins, the antimicrobial possibility

Table 1: Investigation of triclosan concentration on antimicrobial activity of *S. aureus* of finished fabric (bacteria concentration 10^4 CFU/ml)

Recipe name	The amount of bacteria remaining S. aureus (CFU/ml) after locating on fabric x10^4	Bacterial reduction %
Blank	119	0
Triclosan 3g/l	11	90.76
Triclosan 5 g/l	0	100
Triclosan 10 g/l	0	100
Triclosan 20g/l	0	100

Table 2: Investigation of triclosan concentration on antimicrobial activity of E coli of finished fabric (bacteria concentration 10^4 CFU/ml)

Recipe name	The amount of bacteria remaining E.coli (CFU/ml) after locating on fabric x10^4	Bacterial reduction %
Blank	92	0
Triclosan 3g/l	8	91.3
Triclosan 5 g/l	0	100
Triclosan 10 g/l	0	100
Triclosan 20g/l	0	100

of *S. aureus* is much increased. Particularly, the antimicrobial possibility more increased from 88.24 % to 100%. This suggests that, when the best dipping time to S.aureus is 30 mins. If the dipping time is too long or too fast, it is not suitable. However, the dipping time is not much affected to gram negative bacteria when time is raising from 15 min to 45 mins. Clearly, finished samples were not much affected from ambient conditions.

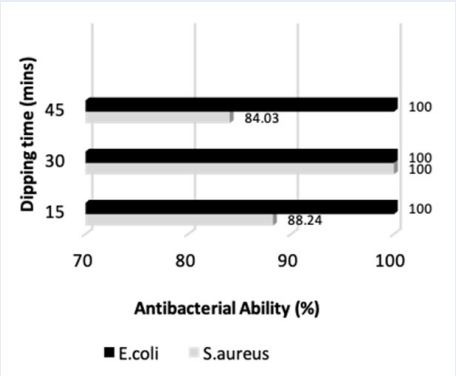


Figure 1: Investigation of dipping time on antimicrobial possibility of S. aureus and E.Coli after finishing

Antimicrobial results from Figure 5 and Figure 6 show that the investigated temperature strong impact the antimicrobial properties of cotton fabric after applying with triclosan solution. At a temperature of 80°C, the cotton fabric gives further improved antimicrobial possibility at 60 °C and 100^0C. The most special property at 60°C is only 94.12 % to gram positive bacteria and 98.63 % for gram negative bacteria. While the sample was at 80°C, the bactericidal ability was 100% for both bacteria. These results are also evident in the images of antibacterial petri dishes. Images on Figure 5 and Figure 6 shows testing for antimicrobial *S. aureus* after investigating at 60°C, 80°C and 100°C.

The possibility of gram negative bacteria resistance in the treated fabric at investigated temperature to 60°C was more great than in the treated fabric to S. aureus at 60°C. From above data of possibility of bacteria resistance to the drying condition of both bacteria, the investigated conditions much impacted the antimicrobial possibility on the materials finishing with triclosan solution. if the temperature is raising, possibility of bacteria resistance is decreasing. Fabrics were treated with temperature of 80°C give the best antibacterial ability.

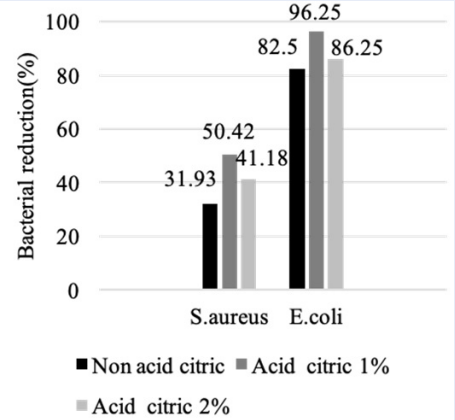


Figure 2: Effect of citric acid concentration on antimicrobial possibility of E.coli and S. aureus of materials after 5 washing cycles

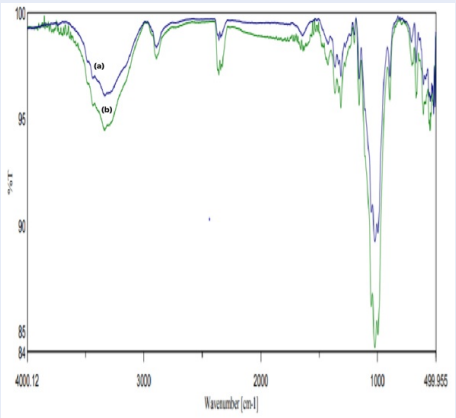


Figure 3: FT–IR image of original cotton fabric (a), finished with triclosan (b).

Examine the effect of washing process and acid citric concentration to antimicrobial possibility after finishing

The materials after finishing with triclosan solution (non citric acid and have citric acid 1%, 2%) are washed five cycles, tested for antibacterial ability.The obtained data were raised in Figure 2.

Figure 3 proved that the laundering procedure decreased antimicrobial possibility of E. coli and S. aureus. Particularly, antimicrobial possibility much reduced after laundering fabric from 100 % to 31.93 % to *S. Aureus*. *E. Coli* fastness also reduces to fiishing product after applying laundering procedure. Resistance to S. Aureus had a stronger decrease than that of E. Coli, specifically, when not washed, all samples reached 100% on both types of bacteria, but after only

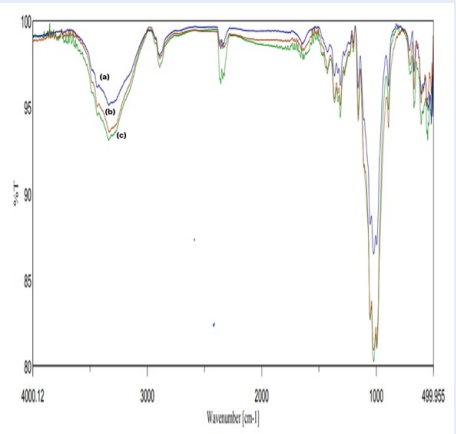


Figure 4: FT–IR image of original cotton fabric (a), treated with triclosan (b), treated triclosan and citric acid 1% (c).

Recipe name	The amount of bacteria remaining S. aureus (CFU/ml) after locating on fabric x10^4	Bacterial reduction %	
Blank	119	0	
60°C	7	94.12	
80°C	0	100	
100°C	2	98.32	

Figure 5: Effect of drying temperature on antibmicrobial activity of *S.aureus* of finished fabric (bacteria concentration 10^4 CFU/ml)

5 times of washing, the ability to microbial resistance in S. Aureus was less than 50%, in E.coli, the resistance was more evident by maintaining the figure above 80%.In addition, when considering each fabric sample treated with 1%, 2% acid and no acid separately, the difference in antibacterial ability can be clearly seen. Specifically, in samples treated with 1% acid, the antibacterial ability of the fabric reached the highest efficiency, even reaching 96.25% for E. Coli bacteria, with acid concentration of 2%, that resistance ability decreased. However, it was still 3.75% higher than the untreated sample. This can lead to the hypoth-

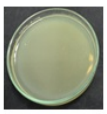
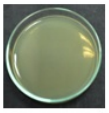
Recipe name	The amount of bacteria remaining E. coli (CFU/ml) after locating on fabric x10^4	Bacterial reduction %	
Blank	93	0	
60°C	1	98.63	
80°C	0	100	
100°C	0	100	

Figure 6: Effect of drying temperature on antimirobial activity of *E. coli* of finished fabric (bacteria concentration10^4 CFU/ml)

esis that acid citric at the suitable concentration can increase the durability of Triclosan on Cotton fabric after washing 5 times. After the finishing treatment, there is a certain amount of triclosan that is bonded to the fabric, and there is also a amount of triclosan that only mechanically sticks to the surface of the fabric, the amount of Trilosan will disappear quickly after the first few washes. Therefore, the antibacterial ability of the fabric decreases. When adding acid at a concentration of 1% during the pressing process, the acid creates cross-linking with the fabric to increase the ability to keep triclosan on the fabric longer, so the antibacterial ability increases significantly after 5 times. However, when used at high concentrations, it can affect the fiber structure, thereby not achieving the best results.

Therefore, basing on above analysis, the antibacterial ability decreases a lot after washing, but we can accept it with the recommended level for users when put into using in textiles industry.

Evaluate bonding level of triclosan to finishing fabric

Figure 3 shows that the results were at the peak 1512.4 cm^{-1}, 1529.27 cm^{-1}, 1549.52 cm^{-1} in the lower (b) line spectrum, corresponding to the oscillation, they are the presence of C-C stretches in the aromatic ring. Therefore, the only the spectrum of the sample treated with Triclosan has this fluctuation, but the spectrum of the untreated cotton fabric sample does not, and this proves that Triclosan has been attached to the Cotton fabric after the finishing treatment.

At the positions where wave oscillations demonstrate the presence of C–O (1052.46 cm^{-1}), –OH (3336.248 cm^{-1}) bonds, the transmittance of the antimicrobial treated sample was much lower than that of the original sample. The absorbance of the antibacterial treated sample is higher than that of the control sample because the reaction increases the hydrogen bonding of Triclosan with cellulose in the fabric and increases the concentration of –OH 3336.248 cm^{-1} on the fabric after treatment. This explains the high antibacterial ability on Cotton fabric after being treated with Triclosan.

Observing the spectrum of the sample treated with acid citric 1% in Figure 4(c), we see that there is an oscillation in the range from 1664.749 cm^{-1} - 1720.192 cm^{-1}, corresponding to this fluctuation is the presence of C=O (shown for presence of acids). Although the oscillation band of the wave is quite narrow, it still shows the presence of C=O bond in acid citric Which has made interaction reaction with cotton fabric and triclosan.

CONCLUSION

The investigation results of research has raised the treatment method in order to obtain antimicrobial on cellulose fabric with dipping-padding-drying process: dipped 30 min with triclosan solution 5 g/l by ethanol, padding at 2.2 bar, drying at 80^{o}C in 5 mins. The optimal technological process has been developed to create an effective antibacterial fabric, with the microbial resistance for both bacteria of 100%, respectively. After investigation, the antimicrobial fastness after 5 washes, we realized that the microbial resistance was still quite high for E.coli bacteria at 82.5% and 31.93% for S.aureus bacteria. It was found that the appropriate concentration of citric acid was 1% added in the process of finishing the sample, to increase the antibacterial ability after washing 5 times. The improved obtained results for the sample is the percentage of E.coli and S.aureus bacteria at 96.25% and 50.42%, respectively, after 5 washes. Antimicrobial finish with Triclosan agent is a heat stable compound, this is an advantage for Triclosan to expand research in many fields and apply to many different materials for antibacterial purposes.

ACKNOWLEDGMENT

We would like to thank HCM city University of Technology and Center for Biotechnology for supporting this study.

CONFLICT OF INTERESTS

The author declares that there is no conflict of interests regarding the publication of this paper.

AUTHOR CONTRIBUTION

Trinh Thi Kim Hue is responsible for all researched content of the article.
Bui Mai Huong edit the article.

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Tạp chí Phát triển Khoa học và Công nghệ – Kĩ thuật và Công nghệ, 4(4):1277-1283

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Bài nghiên cứu

Nghiên cứu ứng dụng triclosan trong hoàn tất kháng khuẩn trên vải cotton 100%

Trịnh Thị Kim Huệ*, Bùi Mai Hương

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TÓM TẮT

Nhu cầu về vải kháng khuẩn gần đây đã tăng lên trong ngành dệt may y tế. Các loại sợi được sử dụng trong các sản phẩm dệt, đặc biệt là các loại sợi làm từ sợi tự nhiên có diện tích bề mặt lớn và khả năng giữ ẩm tốt, tạo môi trường thuận lợi cho vi sinh vật phát triển. Chúng có mặt ở hầu hết mọi nơi và sinh sôi nhanh chóng, tùy thuộc vào độ ẩm, chất dinh dưỡng và môi trường mà chúng sống. Sự phát triển của vi sinh vật trên sản phẩm dệt may đã gây ra hàng loạt tác hại không mong muốn, không chỉ đối với sản phẩm mà còn ảnh hưởng đến người sử dụng sản phẩm. Vải cotton dễ nhăn. Khi tiếp xúc với môi trường ẩm ướt dễ bị vi sinh vật gây hại. Vì vậy, xử lý kháng khuẩn cho vải Cotton 100% là yêu cầu quan trọng trong ngành dệt may tùy theo mục đích sử dụng và là điều kiện tiên quyết đối với các sản phẩm vải trong lĩnh vực y tế. Nhiều tác nhân kháng khuẩn cho hàng dệt may đã được biết đến như hợp chất hữu cơ, phenol, muối amoni bậc bốn. Triclosan là một chất kháng khuẩn và kháng nấm. Triclosan có mặt ở khắp mọi nơi trong cuộc sống từ các sản phẩm tiêu dùng như kem đánh răng, xà phòng, chất tẩy rửa, đồ chơi, đồ gia dụng cho đến mỹ phẩm. Triclosan là chất kháng khuẩn được sử dụng khá nhiều trong ngành dệt may. Triclosan là hợp chất phenol clo hóa, một hóa chất tổng hợp, là chất kháng khuẩn phổ biến và tiềm năng. Trong nghiên cứu này, Các thông số kỹ thuật được khảo sát bao gồm nồng độ Triclosan, thời gian ngâm, nhiệt độ sấy, nồng độ axit citric để đánh giá ảnh hưởng của điều kiện xử lý đến hiệu quả kháng khuẩn của vải cotton. Kết quả cho thấy vải cotton sau khi xử lý xong bằng Triclosan và sử dụng axit citric (CA) làm chất liên kết ngang có hoạt tính kháng khuẩn tốt và cũng cải thiện tính kháng khuẩn bền sau 5 lần giặt. Hoạt tính kháng khuẩn của vải coton được thử nghiệm theo tiêu chuẩn ASTM E2149-01, thử nghiệm được thực hiện với vi khuẩn Escherichia Coli ATCC 25922 và Staphylococus Aureus ATCC 6538.

Từ khoá: Kháng khuẩn, hoàn tất, cotton, vải, triclosan

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Lịch sử

- Ngày nhận: 01-11-2021
- Ngày chấp nhận: 07-01-2022
- Ngày đăng: 14-01-2022

DOI : 10.32508/stdjet.v4i4.930

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Trích dẫn bài báo này: Huệ T T K, Hương B M. **Nghiên cứu ứng dụng triclosan trong hoàn tất kháng khuẩn trên vải cotton 100%.** *Sci. Tech. Dev. J. - Eng. Tech.;* 4(4):1277-1283.