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Multifunctional Properties of Cotton Fabric Treated with Chitosan and RTV Silicone

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Abstract

THE importance of using chitosan and silicon rubber as finishing agents is eco-friendly, natural materials, and perfect antimicrobial agents. Herein, our project is concerned with treating cotton fabric using silicon rubber and chitosan to impart antimicrobial and water-repellent properties to the fabrics. Measurements of antimicrobial activity, morphological test, and contact angle are included in our work.

Keywords: Chitosan, Antimicrobial Finishing, Stain-resistant, RTV silicon

Introduction

Nowadays, cleanliness, contamination-free conditions, and safety are the most important concepts. It was important to create an anti-microbial and stain-resistant cloth.

A massive amount of crab and shrimp shells had been abandoned as global waste. Chitosan is a natural bioactive agent and an excellent antimicrobial agent. So, by using chitosan as an antimicrobial agent, society benefits by reusing waste to create an antimicrobial fabric. This protects the children since they are more vulnerable to resisting bacteria as their immune system is not fully matured. [1-10]

The development of general wear has occurred in response to the need of making life easier and reduce water usage. Being stain-resistant eliminates the need for washing, which benefits society economically. A cloth with a stain-resistant treatment will not allow water or greasy substances to penetrate it, causing possible stains to bead up.. [11]

Silicon rubber in textile finishing has many excellent advantages, it feels rough and hard, which affects the visual effects, tactile effects, and performance of the fabric. Therefore, it is necessary to finish the fiber and textile. Silicone fabric finishing agent has good comprehensive properties, which can not only meet the requirements of wear resistance, tear resistance, wrinkle resistance, straightness, and no ironing, but also soft, elastic, and super smooth, so it is widely used. [12-19]

Silicon creates a highly durable and deep-seated waterproof barrier while maintaining the breathability and porosity of the surface material. It allows textiles to feature both a soft feel and stain repellence, It is possible because to the confluence of three essential characteristics of formulations made of hydrophobic silicone. The silicone molecule has a hydrophobic functional group, which is the first factor. The silicone has a second advantage in that it has great wetting, which enables it to enter the substrate and distribute the hydrophobic functional group throughout or deep into the material. The third is silicon's stability and resistance to oxidative, chemical, thermal, UV, or other stresses. [8-10]

In this study, cotton fabric was the best choice for our work as they make children's clothing strong, flexible, easy to care for, and breathable in any

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condition. Cotton can be coated with both chitosan and silicon in one bath to impart antimicrobial and stain-resistant properties. All the required measurements are carried out and investigated in detail in the paper. [20-23]

Materials, Methods, and Measurements

Materials

Cotton fabric (100%) was kindly obtained from El-Mahalla Company for Spinning and Weaving, El-Mahalla-Egypt.

Toluene, Chitosan (low molecular weight), and silicon are all purchased from Sigma-Aldrich, Egypt. Pigment printing paste was obtained from the local Egyptian market.

Methods

Cotton fabric is treated using the following recipe

Toluene	180 ml
RTV Silicon	20 gm
Chitosan	0, 3, 5, 10 %

At room temperature, 20 gm of RTV silicon is dissolved in 180 ml of toluene and stirred until it becomes homogeneous. The solution is then divided into four equal parts, each containing 50 ml of solution. Different amounts of chitosan (0, 3, 5, 10 gm) are added to the solution while stirring. Four samples of cotton, each measuring 20 x 20 cm, are prepared by dipping them into the solution while stirring for 15 minutes at room temperature. The samples are then pressed and allowed to dry at room temperature before being heated to 100°C for 5 minutes and cured at 150°C for 4 minutes. The treated samples were again dried before being subjected to testing after being rinsed in running tap water.

Measurements

Antimicrobial Test

The disc agar diffusion technique was used to investigate the final cotton samples' antibacterial properties. Staphylococcus aureus ATCC 6538-P (G+ve), Escherichia coli ATCC 25933 (G-ve), Candida albicans ATCC 10231 (yeast), and Aspergillus niger NRRL-A326 were the four typical test organisms employed (fungus). In the case of bacteria and yeast, nutrient agar plates were severely injected on a regular basis with 0.1 ml of 105-106 cells/ml. The antifungal properties were tested using potato dextrose agar plates inoculated with 0.1ml (106 cells/ml) of the fungal inoculum. The inoculation plates were covered with 15mm-diameter textile-treated discs. To allow for maximal diffusion, plates were then maintained at a low temperature (4°C) for 2-4 hours. The plates were then incubated for the bacteria at 37°C for 24 hours and for the organisms to develop as much as possible at 30°C for 48 hours in an upright posture. The diameter of the millimeter-sized zone of inhibition was used to measure the test agent's antibacterial activity (mm). The experiment was run many times, and the mean value was noted.

Scanning Electron Microscopic Measurements Test

Scanning electron microscopic measurements SEM was applied to provide insight into the microstructure of the fiber surface, using SEM Quanta FEG-250 (Czech Republic) in the circumstance of SEM HV: 20.0Kv, WD: 4.86mm, View field: 139μm, Det: SE, SEM MAG: 1.00 kx

Contact Angle Measurement

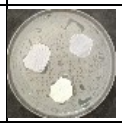
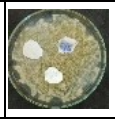
A Drop Shape Analysis Apparatus (DSA100, Krüss Company, Germany) was used to measure the contact angle by performing the sessile drop test by placing a droplet of water on the treated cotton and repeating the process using a Hamilton 500 mL syringe.

Results and Discussion

Measurement of Antimicrobial Activity

Measurements are applied on cotton samples treated with silicon rubber, using 2 concentrations of chitosan which are: 3% and 5% (of fabric weight). Table 1 provides an illustration of the antibacterial activity against several test microorganisms of G+ve bacteria (S. aureus), G-ve bacteria (E. coli), yeast (C. albicans), and fungus (A. niger).

Table 1: *Antimicrobial Activity*

chitosan	Clear zone (ϕmm)			
	Staphylococcus aureus	*Escheichia coli*	*Candida Albican*	*Aspergillusnier*
3%	0	0	12	0
5%	13	0	13	0
10%	15	2	15	0
				

It is obvious from the previous table that, cotton fabrics coated with 5% chitosan gave better microorganism inhibition than the other sample with 3% chitosan.

Surface Morphology

Figure 2 displays SEM images of the surface morphology of an RTV silicon/chitosan film on cotton fibres at various chitosan concentrations (0, 3, 5, and 10%). It is clear from the previous figure that, using a 3% silicon /chitosan treatment is considered the best concentration.

Contact Angle Measurement

A rough surface was prepared by applying a pad-dry-cure method of treatment on the cotton samples

Surfaces coated with silicon/chitosan. A static water contact angle of 162.2 was obtained for the treated samples at a concentration of 50 gm RTV silicon/chitosan as shown in Figure 3.

Hydrophobicity was imparted to cotton by silicone/chitosan. The treated fabric showed excellent hydrophobic properties as the droplets of water rolled off.

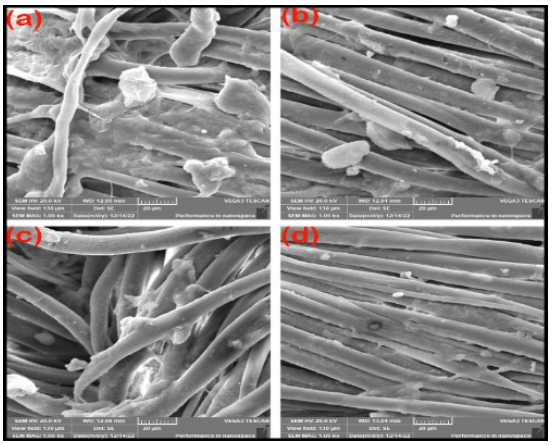


Figure 2 SEM images of treated cotton fabric with RTV silicon /chitosan using different concentration

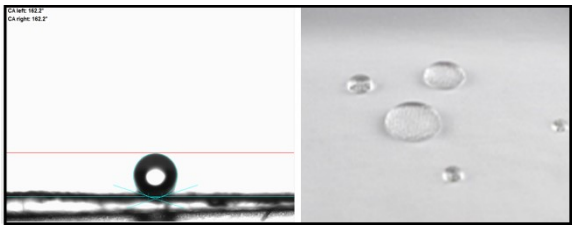


Figure 3 contact angle of treated cotton fabric using 3% of silicon /chitosan.

Cotton Surface Images

Fig. 4 represents zoomed pictures of treated cotton. Which shows the difference in the structure of the cotton.

There is a difference in the cotton surface caused by different chitosan concentrations (0, 3, 5, 10 %) of fabric weight. that are used in the RTV/chitosan solution. The pores showed different filling percentages in the 3% and 5% chitosan which are moderately filled.

This gives good air permeability and good antimicrobial protection, unlike the 10% concentration where the pores are almost filled, which makes it unbreathable. The untreated sample gives bad antimicrobial resistance.

Conclusions

In this study, cotton fabric is treated with eco-friendly materials like chitosan and harmless RTV silicone utilising the pad-dry-cure procedure in an effort to give the cloth antibacterial and water-repellent qualities. Cotton inhibited a variety of bacteria by adjusting the chitosan content in the depositing solution. The cloth underwent morphological, contact angle, and antimicrobial testing; the results are shown in our study. Cotton might be treated with an antimicrobial finish that is effective against Gram-positive bacteria like S. aureus and Gram-negative bacteria like E. coli. Thus, cotton fabrics may be given an eco-friendly, multipurpose finish using the suggested process.

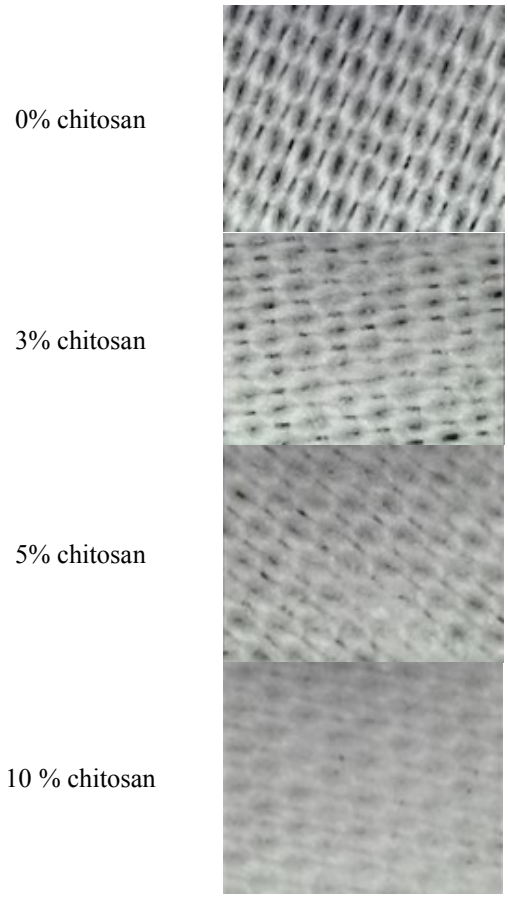


Fig.4 untreated and treated cotton fabric with different concentrations

Conflict of Interest

There is no conflict of interest in the publication of this article.

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التجهيز المتعدد للاقمشة القطنية باستخدام الكيتوزان والسليكون المطاطي

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المستخلص: أهمية استخدام الكيتوزان ومطاط السيليكون كعوامل تجهيز هي مواد صديقة للبيئة وطبيعية وعوامل مثالية مضادة للميكروبات. هنا ، يهتم مشروعنا بمعالجة الأقمشة القطنية باستخدام مطاط السيليكون والكيتوزان لإضفاء خصائص مضادة للميكروبات وطاردة للماء على الأقمشة. يتم تضمين قياسات النشاط المضاد للميكروبات والاختبار المورفولوجي وزاوية الاتصال في عملنا.

الكلمات المفتاحية: الكبتوزان ، مطاط السيليكون ، مقاومة البقع ، مضادات الميكروبات