



CHITOSAN COATED COTTON YARN AND IT'S EFFECT ON ANTIMICROBIAL ACTIVITY

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ABSTRACT

A new cotton yarn with a chitosan coating was prepared by the oxidation of a cotton thread with sodium periodate at 60°C in water and subsequent treatment with a solution of chitosan in aqueous acetic acid. Infrared spectra of the chitosan coated cotton yarn suggested the formation of Schiff's base between the chitosan and the oxidized cellulose. Scanning electron microscope (SEM) photographs showed that the surface of the chitosan coated cotton yarn was slightly changed after the series reaction. Furthermore, the antimicrobial activity of the chitosan coated cotton thread was evaluated.

Keywords: cellulose; sodium periodate; chitosan; cotton yarn

1. Introduction:

In recent years, great attention has been devoted to biopolymers because of their biocompatibility and biological functions and consequently, potential application in the biomedical and pharmaceutical fields [Alok R. Ray & Dinesh K. (2000)]. Chitosan, a polymer having β -1, 4 linked glucosamine residues, is produced by deacetylation of chitin, the second most abundant polysaccharide found on earth next to cellulose. Chitosan has a great potential for a wide range of uses due to its biodegradability, biocompatibility, antimicrobial activity, non-toxicity and ability to improve wound healing and therefore, it is evaluated in a number of medical applications [Kailash C. Gupta (2000)].

The aim of this work was to modify the cotton yarn in such away that, it would react

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with chitosan polymer in aqueous acetic acid solution. The fixation of chitosan polymer on cotton was done by immersing the cotton yarn in chitosan solution for a specified temperature and duration with constant stirring. The infrared spectra analysis, scanning electron microscope analysis and antimicrobial activity of the chitosan coated cotton yarn were evaluated.

2. Experimental

2.1 Materials

All chemicals used for the following investigations were of analytical grade. Chitosan with an N-deacetylation degree of 0.82 ($\eta = 300$ cps) was obtained from Central Institute of Fisheries Technology, Kerala and cotton spinning thread (11/ 2 Ne) was obtained from lab.

2.2 Methods

2.2.1 Modification of cotton yarn with sodium periodate

A reel of scoured thread was immersed in solution of sodium periodate in deionized water (400 ml) at concentrations of 1.0 mg/ml. The solution was then stirred for 1 h at 60°C. According to the reported procedure (N. Sakairi, S. Tokura March-2000), the cotton thread was washed with deionized water several times to remove the oxidant, and soaked in deionized water (400ml) at ambient temperature. This oxidized material was used for the next reaction without drying.

2.2.2 Treatment with chitosan

The chitosan solution was prepared by stirring a dispersion of chitosan (2.0 g) in 2.0% (v/v) aqueous acetic acid solution (100 ml) for 1 h at 60°C. The above mentioned oxidized cotton thread was immersed in the chitosan solution with constant stirring for 2 h at 60°C. According to the reported procedure (N. Sakairi, S. Tokura March-2000), the material was washed with deionized water several times and dried at 60°C for 25 minutes to produce the drug carrier cotton thread.

2.2.3 Measurement

2.2.3.1 Instrumental analysis

The oxidized material and chitosan coated cotton yarn were used for the following instrumental analyses. Infrared spectra were recorded using a Horiba FT-210 spectrophotometer with a potassium bromide pellet. Scanning electron microscopy (SEM) photographs were taken on a Hitachi S-2400 instrument operating at 12-18 Kv after sputtering with gold.

2.2.3.2 Antimicrobial Test

SHAKE FLASK METHOD- The shake flask method was approved by the Association of Antibacterial Treatments of

Textile, Japan. [T. Oktem 2003] This standard method was used to measure the reduction rate in the number of colonies formed and provided quantitative data, which could then be converted, to the average colony forming units per milliliter (CFU/ml) of buffer solution in the flask. The reduction rate in the number of colonies was calculated using the following formula:

$$\text{Reduction rate (\%)} = \frac{B-A}{B} \times 100$$

Where A = CFU/ml for the flask containing the treated substrate after 3 h and 6 h contact time

B = CFU/ml for the flask at time zero, prior to the addition of the treated substrate.

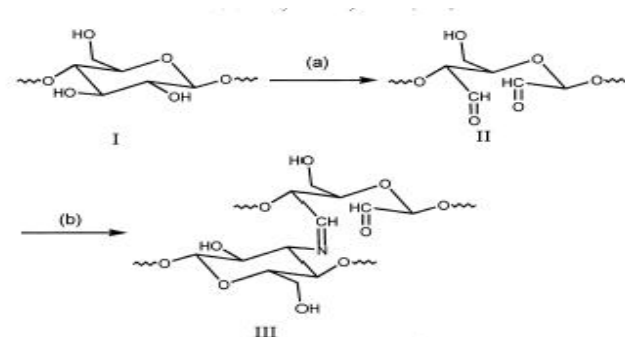
The test tube was shaken at 37°C for 3 h and 6 h on a rotary shaker and 100 µl of the serially dilute test solution was added to the agar plate and incubated at 37°C for 24 h and the number of colonies in the agar plate was counted.

3. Results and Discussion

3.1 Preparation of chitosan coated cotton yarn and FTIR analysis

The preparation process of chitosan coated cotton yarn is summarized in Figure 3.1.1 (reagents and conditions: (a) NaIO₄, 60°C, 1 h; (b) chitosan, CH₃COOH (2% (v/v)), 60°C, 2 h). According to the reported procedure (N. Sakairi, S. Tokura March-2000), the cotton thread was first oxidized by sodium periodate to cleave the 2, 3-vicinal diol of the cellulose glucose units (I), giving the so-called dialdehyde cellulose (II). The resulting aldehyde group on the cellulose fiber would possess the ability to couple with an amino group of chitosan. Treating the thread with a chitosan solution in acetic acid, as a result the Schiff's base formation between the oxidized cellulose and the chitosan.

www.greatvistachemicals.com/biochemicals/chitosan.html



Cellulose glucose units (I) dialdehyde cellulose (II) chitosan coated cotton (III)

Figure 3.1.1 Chemical Reaction between oxidized cellulose and chitosan

The reaction process was monitored by infrared spectroscopy. Figure 3.1.2 shows the spectra of cellulose oxidized with sodium periodate and chitosan coated cotton thread. The characteristic absorption band of the oxidized cellulose clearly appeared at 1737.23 cm^{-1} due to the stretching vibration

of the C=O double bond of the aldehyde group. After treatment with chitosan, the characteristic absorption band shifted to 1645.14 cm^{-1} suggesting that the Schiff's base (C=N double bond) was formed between the aldehyde group and chitosan.

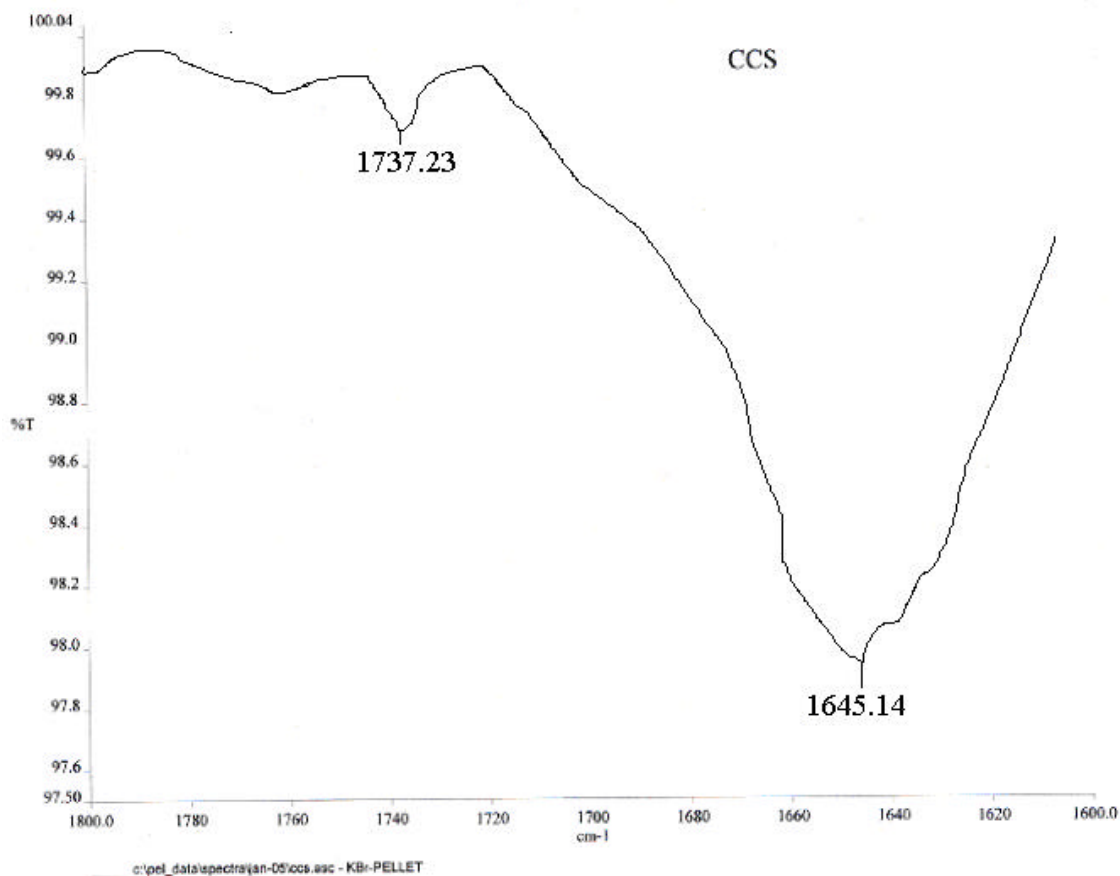


Figure 3.1.2 Infrared Spectroscopy Analysis of Oxidized Cellulose

3.2 Scanning Electron Microscopic (SEM) analysis

The Surface of chitosan coated cotton yarn and oxidized material were morphologically observed by scanning electron microscope (SEM). Many small grains were observed on the surfaces of the chitosan coated cotton yarn as shown in

Figure 3.2.1 On the other hand; the surface of the oxidized cotton material had many long and narrow lines Figure 3.2.1 From the SEM analysis, it was clear that the chitosan coated cotton yarn surfaces had a same morphological form, which is different from the unmodified cotton fiber that showed a smooth surface.



Chitosan Coated Material

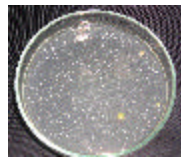
Oxidized Material

Figure 3.2.1 Scanning electron microscope (SEM) Analysis of chitosan coated cotton thread

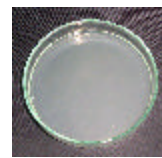
3.3 Antimicrobial activity of chitosan coated cotton yarn

The shake flask method was used, which measures antimicrobial activity quantitatively, to determine the effectiveness of the treatment in reducing the bacterial colony counts of E. coli and S. aureus [Sang-Hoon Lim and Samuel M. Hudson

(2003)]. From the Figure 3.3.1 and 3.3.2, it was observed that there was 100 % reduction of the number of colonies in the chitosan coated cotton sample against E. coli and S. aureus bacteria's, the result was tabulated below 3.3.1



Uncoated sample

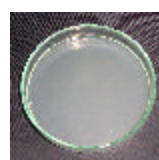


Chitosan coated sample

Figure 3.3.1 Escherichia coli bacterial growth against chitosan coated samples



Uncoated sample



Chitosan coated sample

Figure 3.3.2 *Staphylococcus aureus* bacterial growth against chitosan coated Samples

From the Table 3.3.1, it was observed that there was 100 % bacterial reduction in chitosan coated cotton sample against *E. coli* and *S. aureus* bacteria.

Table 3.3.1 Antimicrobial activity of the samples against *E. coli* and *S. aureus*.

S. No	Sample	Bacteria	Antimicrobial activity %	
			Microorganisms growth	Bacterial reduction (%)
1	Uncoated sample	<i>E. coli</i>	294	-----
2	Chitosan coated sample	<i>E. coli</i>	Nil	100
3	Uncoated sample	<i>S. aureus</i>	234	-----
4	Chitosan coated sample	<i>S. aureus</i>	Nil	100

4. Conclusion:

The present work consists of development of antimicrobial textiles by coating chitosan over cotton yarn and investigating their antimicrobial activity. The chemical modified cotton thread with a chitosan coating was obtained by the reaction between aqueous chitosan acetic acid and the oxidized cotton thread. From the Scanning electron microscope (SEM) analysis, the smooth surface of the cotton fiber became rough. The antimicrobial activity of the chitosan coated cotton material shows 100 percent activity. Hence, this novel thread is suitable for use as wound healing and antibiotics and antibacterial.

Acknowledgement:

The author wish to express his deep sense of gratitude to Dr. M. Madhusoothanan, Professor & Head and Mr. V.R. Giridev, Lecturer, Department of Textile

Technology, Anna University, Chennai for their invaluable guidance during this work. My special thanks to Scientist, Central Institute of Fisheries Technology, Kerala for providing chitosan polymer to do this work and also grateful to Dr. Suseela Rajkumar, Director, Central Leather Research Institute, Chennai for providing facilities and guidance to do the bacterial test.

References:

1. Alok R. Ray & Dinesh K (2000), 'Biomedical Application of Chitin, Chitosan and Their Derivates', *Journal of Macromolecular Science*, C40 (1), pp.69-83.
2. Kailash C. Gupta (2000), 'An Overview on Chitin and Chitosan Applications with an Emphasis on Controlled Drug Release Formulations', *Journal of Macromolecular Science*, C40, pp.273-308.

3. Liu .X.D and Nshi. N (2001) & (N. Sakairi, S. Tokura March-2000), 'Chitosan Coated Cotton Fiber: Preparation and Physical properties', *Elsevier Journal, Carbohydrate Polymers* Vol.44, pp.223-238.
4. Pradip Kumar Dutta (2002), 'Chitin and Chitosan for Versatile Applications', *Journal of Macromolecular Science*, Vol.C42, No3, pp.307-354.
5. Sang-Hoon Lim and Samuel M. Hudson (2003), ' Review of Chitosan and Its Derivatives as Antimicrobial Agents and Their Uses as Textile Chemicals', *Journal of Macromolecular Science*, Vol.C43, pp.223-269.
6. Tulin Oktem (2003), 'Surface treatment of cotton fabrics with chitosan', *Coloration Technology*, Vol.119, pp.241-246.
7. www.greatvistachemicals.com/biochemicals/chitosan.html

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