Antibacterial Coating Of Herbal Biopolymer Nanocomposite On Bamboo Cotton Fabric For Textile Applications

DR. Banupriya.J, **DR. V. Maheshwari**

ABSTRACT: The healthcare and sanitation textiles are gaining additional importance for the eco-friendly and valuable antibacterial activity that have become vital to safegaurd human beings from harmful microorganisms. Most of the antibacterial agents available in the market for the application of textiles are synthetic-based and may not be environmentally friendly. Among the improvement of textile with Antibacterial finish it is greatly essential and appropriate since garments are in direct contact with human body. The present investigation is to develop a fabric with antibacterial property using Terminalia chebula herb and Chitosan biopolymer extracts. Antibacterial property has been imparted to bamboo cotton blended fabric using nanoencapsules by exhaust method. The antibacterial activity was assesed using Agar Diffusion Method against Gram Positive organism (Staphylococcus aureus) and Gram Negative organism (Escherichia coli). The samples were imparted with herb and biopolymer nanocapsules which showed best results for antibacterial activity against microbes even after 30 washes. The finished sample was analyzed for its morphology using FESEM and FT-IR.

Key words: Antibacterial property, herbal extract, biopolymer extract, nanocapsules.

1. INTRODUCTION

Textiles have such a significant role in our regular breathes that everyone need to understand about the growth of textiles[4]. Bamboo fabric has a high demand in the market because of their antibacterial nature, softness, biodegradable properties, high moisture absorption capacity and Ultraviolet Protection capability[6]. Cotton composes of cellulose and hemicellulose which is the most abundant natural polymer on the Earth. Finishes must be durable and stable in the presence of other chemicals, along with wash fastness when applied evenly and consistently. Finishes also need to be financially feasible and environment friendly[5]. In the attempt to utilize the waste available in huge quantities, Biopolymers extracted from waste have been utilized for useful applications in textiles. Medicines derived from plants have been a part of our traditional health care system. Many of the plants used today were well known to the people of ancient cultures throughout the world and they were valued for their preservation and medicinal powers. The medicinal plants used as medicine were considered to be important due to a large number of factors such as availability, inexpensiveness and the required functions in them. Antibacterial finishes for textiles and other surfaces that act without the release of biocides to the environment or by inhibiting microbial adhesion are viewed as promising and environmentally friendly alternatives to current products.

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Recent studies have enabled the use of nano particles in medicine to unlock new frontiers in diagnosing, treating, and preventing disease; relieving pain; and preserving and improving human health. Among other bioapplications, nanotechnology has potential to create revolutionary products in regenerative medicine and tissue engineering. Nanocomposites are currently being used in a number of fields and new applications are being continuously developed. Composites are formed by the combination of two or more materials that have quite different properties. The concept of composite materials is ancient: to combine different materials to produce a new material with performance unattainable by the individual constituents [2]. From the findings, ethanolic extract of Terminalia chebula herbal extract and Chitosan biopolymer extract has been reported to act against microbial infection. Some studies reported Terminalia chebula can be a potential dietary component which can help in prevention of different diseases. Chitosan is produced from natural sources which are nontoxic, biodegradable and biocompatible natural polymer mainly used for pharmaceutical and medical applications.

2. MATERIALS AND METHODS

2.1 Collection and preparation of herb extraction

The herbal extract selected for the present study was fruit of Terminalia chebula which was collected in and around Coimbatore. Fruit of Terminalia chebula was washed with sterilized distilled water and dried. The substrate was passed through sieve to separate the unwanted residue to obtain fine powder.

2.2 Collection and preparation of biopolymer extraction

The Chitosan biopolymer which was extracted from crab shell was collected from fish market, Coimbatore. The crabs' exoskeletons were placed in 250 ml beakers and treated in boiling sodium hydroxide (2% and 4% weight/volume) for one hour in order to dissolve the proteins and sugars which isolated the crude chitin. After the samples were boiled in sodium hydroxide, the beakers containing the crab shell samples were removed from the hot plate and then allowed to cool for 30 minutes at room temperature. The exoskeletons were then further crushed to pieces of 0.5 -5.0 millimeter using a mortar and pestle.

2.3 Synthesis of Nanoparticles from Herbal and biopolymer Extraction

The Nanoparticles were synthesized by using each 100 ml of Herbal extracts solvents of the fruit of Terminalia chebula and Chitosan biopolymer. Initially 250 ml of sodium alginate (base solution) (3.35mg/ml) was prepared, followed by 150 ml of calcium chloride (3 mg / ml) preparation. The calcium chloride ($CaCl_2$) solution was added drop by drop into sodium alginate solution with constant stirring at 1500 revolutions per minute at room temperature for 30 minutes. Then the Herbal extract was added separately to the mixture very carefully drop by drop to the above solution with constant stirring for 45-60 minutes. The mixture was kept undisturbed overnight. After incubation, the uppermost layer was discarded and the pellets were collected and characterized for further research.

2.4 Preparation of Herbal Biopolymer Nanocomposite

In order to synthesize the composite, vortex method was used for the synthesis of Herbal Biopolymer nanocomposites. The mechanical mixing process was appropriate for preparing Herbal Biopolymer nanocomposites. 250 ml of Herbal nanoparticles solution (1% wt./wt. in acetic acid) and 250 ml of Biopolymer nanoparticles solution (1% wt./wt. in water**)** (1:1) were mixed in 1000 ml beaker and stirred for one hour at 60ºC to obtain a homogeneous solution. The speed of the stirrer can be varied as the setup has a speed controller attached to it. To this solution, one milliliter of two percent glutaraldehyde solution in water is added under stirring at room temperature (25ºC). The nanocomposite prepared was subjected to nanoencapsulation.

2.5 Fabric finishing with Nanocomposite by Exhaust method (Nanoencapsulate Herbal Biopolymer)

To finish the fabric, a sample of about one liter solution containing 600 grams of nanocapsules was used. The fabric was immersed in the Herbal Biopolymer nanoencapsulate solution along with binder solution (8% citric acid) for 30 minutes under 50ºC in an oven. After 30 minutes, the fabric was removed and air dried in shade.

2.6 Assessment of Antibacterial activity of Nanoencapsulate fabric by AATCC 147 method

The treated Nanocomposite finished fabric samples by AATCC Bacteriostasis agar plates were prepared by pouring 15ml of AATCC Bacteriostasis agar media into sterile petri plates. The plates were allowed to solidify for 10 minutes and the bacterial culture was inoculated as single line followed by the four lines without refilling the inoculation loop. The nanoencapsulate fabric sample was cut into 5 X 2.5 cm size with the diameter of 2.5 cms placed over the inoculated bacterial species. And the plates were kept for incubation at 37ºC for 24 hours. At the end of incubation, a zone of incubation formed around the fabric was measured in millimeter and recorded. The same procedure was repeated for evaluating the antibacterial activity of 10th washes, 20th washes and 30th washes of the nanoencapsulate fabric samples.

2.7 Determining the biocompatibility of the finished sample using standard HET-CAM

HET-CAM (Hen's egg test-chorio allantoic membrane) method uses the vascular fetal membrane of chicken embryos. It is assumed that acute effects induced by a test substance and the small blood vessels and proteins of this soft tissue membrane are similar to effects induced by the same test substance in the skin of a treated rabbit. The membrane was evaluated for the development of irritant endpoints [(1)].

2.8 Field Emission Scanning Electron Microscope (FESEM)

The surface morphology of controlled and finished fabric samples were analyzed using field emission scanning electron microscope [(3)]. The scanning electron microscope radiates high energy electrons in a focused beam to generate a variety of signals on the surface of the fabric samples.

3. RESULTS AND DISCUSSION

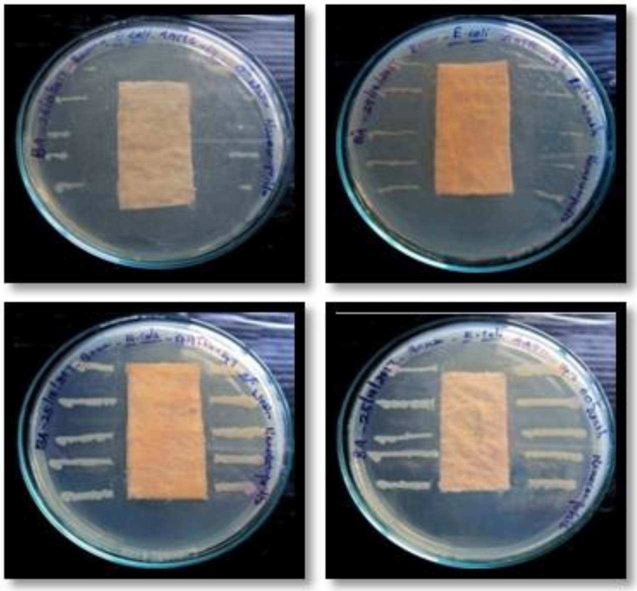
3.1 Antibacterial efficacy of the Nanoencapsulate finished and washed fabric samples by AATCC147 method

Qualitative antibacterial assessment of the Herbal Chitosan nanoencapsulate finished and washed samples were depticted in the below table.

Sl. no.	Fabric Samples	Zone of inhibition (mm)	
		Escherichia coli	***Staphylococcus aureus***
1	Controlled Sample	0	0
2	*Terminalia chebula* and Chitosan bipolymer nanoencapsualtion	44	46
3	After ten washes	42	41
4	After twenty washes	38	39
5	After thirty washes	35	33

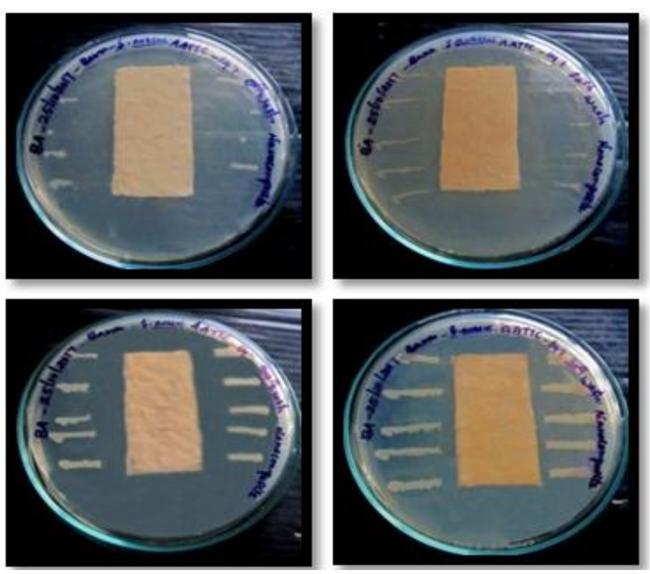
From the assessment, herbal and biopolymer nanoencapsulate sample, the treated sample showed good antibacterial property and even after thirty washes the sample showed good zone of inhibition in both Escherichia coli and Staphylococcus aureus.

Wash durability of the Antibacterial activity of the Nanoencapsulate fabric sample and their 10, 20 and 30 washed samples against Escherichia coli



1. Treated Sample 2. After 10 washes 3. After 20 washes 4. After 30 washes

Wash durability of the Antibacterial activity of the Nanoencapsulate fabric sample and their 10, 20 and 30 washed samples against Staphylococcus aureus

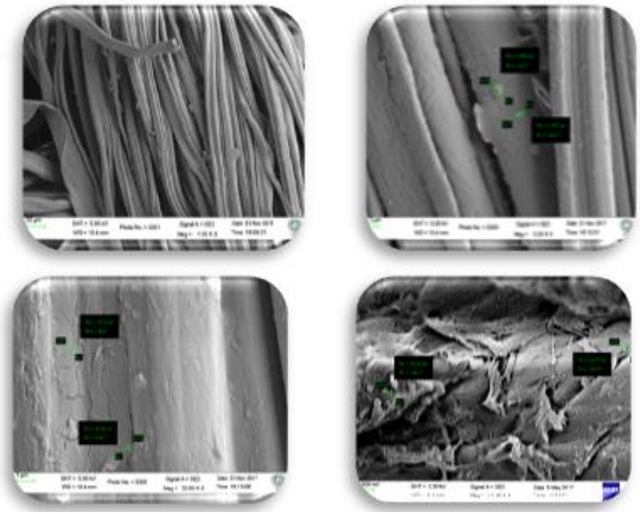


1. Treated Sample 2. After 10 washes 3. After 20 washes 4. After 30 washes

3.2 Analysis of the Nanoencapsulate fabric sample by Fourier Transmission Scanning Electron Microscope (FESEM)

The surface topography of the nano encapsulate fabric sample was observed using Fourier transmission scanning electron microscope (FESEM). The characteristic of the nanoencapsulate fabric sample was analyzed.

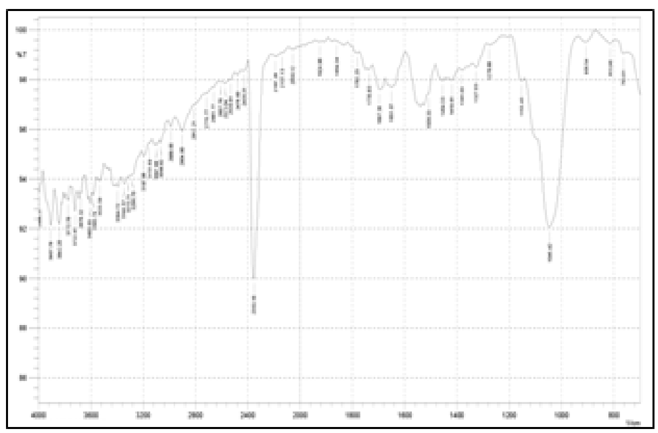
FESEM imaging of the nano encapsulate fabric sample



The Fourier transmission scanning electron microscopic images of the bamboo/cotton woven nano encapsulate fabric sample. The imaging was done with different magnifications like 1.00KX, 5.00KX, 20.00KX and 43.46KX. The images of the FESEM showed the extracts were fixed to the yarn as nanocapsules.

3.3 Analysis of Fourier-Transform Infrared Spectroscopy (FT-IR) with Nanoencapsulate finished fabric sample

The functional group of the Nanoencapsulate finished fabric sample was identified by using Fourier-transform infrared spectroscopy (FT-IR).



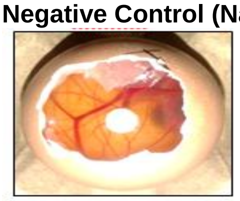
The FT-IR spectrum was used to discover the functional group of the different components based on the peak value in the area of infrared radiation. The functional group identification is based on the FT-IR peaks attributed to the stretching and bending vibrations. The result of FT-IR analysis revealed the presence of alkenes, 1°, 2° amines, aliphatic amines, Alkenes, alkynes, aldehydes, alkynes, aromatics and nitro compounds

3.4 Analysis of Hen's Egg Test – Chorioallantoic Membrane (HET CAM) with the Nanoencapsulate finished fabric sample

It was clear from the relationship of scores with category of irritation that the nanoencapsulate fabric sample (Herbal Chitosan Biopolymer) showed no irritation against Hen's egg test.

Materials on CAM	Endpoint development			Irritation score[1]
	Haemorrhage	Hyperemia	Coagulation	
Negative control	0	0	0	0
Positive control	5.9[1]	6.7[1]	6.3[1]	18.9[2]
Nanoenpsulate fabric sample	0	0	0	0

Negative Control (NaCl)



Well-developed blood endpoint vessels observed on CAM (No Irritant End Points)

Positive Control (NaOH)

All three irritant were evident (Lysis, Hemorrhage and Coagulation)

Well-developed blood vessels observed on CAM (No Irritant End Points)

The selected Nanoencapsulate fabric sample did not develop any irritant end points, which revealed that the samples were biocompatible in nature. The obtained results were thus compared with negative controlled samples which had also showed nil irritant endpoints. Whereas, the positive controlled sample showed all the three irritant endpoints. The mean value of the time taken for the development of hemorrhage, hyperemia and coagulation were identified as 5.9, 6.7 and 6.3 seconds respectively

4. CONCLUSION

Thus, from the results obtained, it can be concluded that purpose of antibacterial finish on bamboo/ cotton fabrics by using herbal and biopolymer nanoencapsulation method improved antibacterial properties to a greater extent thus leading to excellent protection. The fabric when finished by nanoencapsulation method exhibited superior functional properties and good wash durability even after several washes. This type of textile material can be used for children's wear and it can also be used for surgical gowns.

5. REFERENCES

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