

Development of Combination Herbal Nano-encapsulated Healthcare Apparel for Psoriasis

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Abstract

The work is aimed to impart medicinal property to 100% organic cotton, 100% bamboo and cotton/bamboo blended knitted fabrics by treating them with nano-capsules of combination medicinal herb extracts and identification of best fabric to care against psoriasis. The best combination medicinal herbs which can control psoriasis were identified as neem (*azadirachta indica*), wild turmeric (*curcuma aromatica*) and tulsi (*holy basil*). The fabrics were pre-treated using natural methods without using any chemicals and the herbal extracts were prepared using methanol extraction. The pre-treated fabrics were finished with nano-capsules of the combination medicinal herb extracts using pad-dry cure method with optimized process parameters. The developed fabrics were tested for their antibacterial activity against Bacteria *Staphylococcus aureus* and *Escherichia coli* using bacterial reduction test. The antibacterial test results show that all the treated fabrics have excellent antibacterial activity against both the test organisms. The developed fabrics were also tested for contact allergy using patch test. The test results showed that all the treated fabrics have no irritant reaction to the wearers. This clearly confirms that all the treated fabrics do not cause any irritation to the people who are affected with psoriasis. The comfort properties analysis shows that 100% bamboo nano-encapsulated fabric showed best results with regard to water absorbency, thermal conductivity, drapeability characteristics; nano finished 100% organic cotton fabric showed best results with regard to water vapour permeability characteristics. In Fourier transform infrared spectroscopy analysis, the presence of active components has been confirmed. The scanning electron microscope analysis also confirmed the presence of nano-capsules on the fabric structure. From the anti bacterial test results, surface characteristics analysis and comfort property analysis, the best treated fabric was identified as 100% bamboo fabric from the statistical analysis.

Index Terms— Bamboo fabric, Combination medicinal herb extract, Healthcare apparel, Psoriasis

I. INTRODUCTION

Substances obtained from the plants continue to be the basis for many commercial medications used today for the healing of many diseases. India's one of the well known medicine system, Ayurveda had a division called Ayurvastra. Ayurvastra or medicinal cloths, which are treated with medicinal herbs and oils helps to promote health and cure some specific diseases when the wearer wears it. To import additional value to the garments, several manufacturers are producing herbal treated clothes. Although herbal clothing is a very old concept, but growing interest among the people in sustainability and natural healing is creating a niche market for herbal clothes. Since the herbs have many medicinal properties such as anti-allergic, anti-septic and anti-bacterial functions, the herbal treated clothes can be used to care against some specific diseases especially for skin diseases. Herbal clothing is advisable to all sorts of people even to those without skin problems as a precautionary measure. In recent past, the rising expectations for herbal products from the consumers has show the way to the idea of linking the alternate medical concept and textiles to develop most effective eco-friendly health care apparels.

II. RELATED WORKS

Despite the fact that the uses of antimicrobials have been recognized for the decades, it is only in the recent times, attempts have been made on treating textiles with antimicrobial compounds. The consumers are now increasingly conscious of the hygienic lifestyle and there is scope and demand for a variety of textile products finished with antimicrobial properties [1]. In the existing situation of environmental awareness, the new quality requirements not only give emphasis to the essential functionality and durability of the product but also the production process is expected to be eco-friendly. Hence developmental activities on safe antimicrobial agents based on natural products for textile application is rapidly growing. Many types of active ingredients are found in the extracts of natural products [2]. The relatively lower incidence of negative effects on herbal products as compared to modern synthetic chemical compounds, coupled with their low cost, can be used as an attractive eco-friendly choice to

synthetic antimicrobial agents for textile applications. Natural dyes can be very useful in providing antifungal as well as antimicrobial properties to textiles as they are known for dyeing and other medicinal properties but their structures and other properties have been recognized only in the recent past only [3-4]. The antimicrobial treatment of textiles is proposed to provide guard for textiles against microbial corrosion, avoidance of malodor or prophylaxis and therapy of infections, respectively. For every biocidal product, a cautious risk assessment for humans and the environment has to be carried out. The benefit of antimicrobially active textiles has to be documented for every agent as well as for every application, and a balance has to be found between a textile's quality rating and the potential risks such as sensitization, disturbance of the ecology of the skin, toxic side effects by means of systemic absorption, cytotoxicity, etc., The antimicrobial treatment of textiles for deodorization purposes has to be avoided. Now, from a hygienic point of view, the following questions have to be noticeably determined: declaration of any antimicrobial treatment; development of international standards for in vitro testing and preclinical evaluation of efficacy and tolerance; evaluation of the benefit of the antimicrobial properties for the aimed use including the risk-benefit assessment [5]. From the related works, it was clearly understood that any healthcare textiles development should focus on not only its healthcare potential but also its safety and comfort aspects. . The main aim of the work is to embed medicinal property to 100% organic cotton, 100% bamboo and cotton/bamboo blended knitted fabrics by treating them with nano-capsules of suitable combination medicinal herb extracts and at the same time an attempt is made to identify the best fabric material suitable for caring against the psoriasis by providing it with medicinal, safety as well as comfort to the people who are suffering from psoriasis.

III.METHODOLOGY

A.Materials

The particulars of the materials such as medicinal herbs, textiles used in the developmental work are given below.

1)Textiles

The particulars of 100% organic cotton, 100% Bamboo and bamboo/cotton blend knitted fabrics used for the development of health care apparel are furnished in Table I.

Table I. Knitted fabric particulars used for the development of health care apparel

Particulars	100% organic cotton	100%bamboo	Cotton/bamboo blend
Fabric structure	Single jersey	Single jersey	Single jersey
Yarn count (Ne)	40s	40s	40s
TPI	20.62	21.87	20.87
Wales /inch	47.2	44.4	43.6
Course/inch	36.2	33.3	36
GSM	130	130	130
Loop length(mm)	3.2	3.2	3.2

Tightness factor	13.86	13.86	13.86
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2)Medicinal Herbs

The particulars of the medicinal herbs used for the development of health care apparel are furnished in Table II.

Table II. Medicinal herbs particulars

Common name for the medicinal herbs used	Botanical name for the medicinal herbs used	Parts used
Neem	Azadirachta Indica	Leaves , bark
Wild Turmeric	Curcuma aromatic	Rhizome
Holy basil	Ocimum sanctum	Leaves

B.Methodology

Knitted fabrics (100% organic cotton, 100% bamboo and cotton/bamboo blend) were given the following pre-treatment processes to enable the fabrics fit for developing eco-friendly health care apparel without any usage of chemicals.

1) Natural scouring

The scouring process was carried out in the solution containing 10% neem tree bark ash with M:L Ratio of 1:10, pH as 12.0 at 90 degree celsius for 3 hours and washed a number of times till the material brought to neutral pH.

2) Natural bleaching

The scoured fabrics are exposed to direct sunlight with the use of a natural grass base which carries out the natural bleaching process through photolytic oxidation process.

3) Extraction of Herbal powders

For extraction, 6g of dry powder from each herb (Neem leaves power, Turmeric and Tulsi leaves was taken separately and mixed into 50 ml of 80% Methanol. The container was closed and kept overnight at room temperature for herbal extraction. After overnight incubation, the extract was filtered through filter paper and evaporated to concentrate the extract. The condensed extracts were used for nano-capsules preparation.

4) Preparation of nano-capsules for the herbal extracts

Calcium chloride solution and sodium alginate were used for herbal nano-capsules preparation. About 7.0 mg of calcium chloride was dissolved to obtain 2.0 ml aqueous suspension. The prepared solution was added drop wise to sodium alginate solution prepared at concentration of 30 mg / 10 ml. Care was taken during addition. The mixed solution was stirred continuously at 1500 rpm for 30 minutes at room temperature. After 30 minutes, the prepared suspension was used for herbal nano-capsule preparation. The herbal extracts were mixed in 1:1:1 proposition and the mixed extract were added to the suspension of calcium chloride and sodium alginate at concentration of 4.0 ml. The contents were stirred for 45 – 60 minutes. After stirring, the contents were left undisturbed for overnight. The next day, the uppermost clear

liquid layer was discarded and the remaining pellet was used for finishing the fabrics by pad – dry – cure method.

5) Particle size analysis

The size of nano-capsule is analysed using particle size analyzer (PSA).

6) Finishing of health care fabrics by Pad-dry-cure method

The fabric sample immersed in the herbal nano-capsules was passed through a laboratory padding mangle. The herbal nano-capsule suspension was finished on the fabric by heating the solution to 60 °C in water bath. The solution was padded at pressure of 20 kgf/ cm². The speed was maintained at 15 m/min and padded the fabric for 30 minutes. The padded fabric was air-dried and then cured for 3 min at 140 °C.

7) Testing of Eco-friendly Healthcare Fabrics

To determine the effectiveness of the combination medicinal herb extracts treated 100% organic cotton, 100%bamboo and cotton/bamboo blend fabrics; the following tests have been carried out.

7.1.Anti bacterial test

7.2.Anti Allergy test

7.3. Fabric surface analysis tests:-

- Fourier Transform Infrared(FTIR) Spectroscopy Analysis
- Scanning Electron Microscope (SEM) Analysis

7.4. Comfort property tests

- Air permeability test
- Water vapour permeability test
- Water absorbency test
- Drapeability test
- Thermal conductivity test (lee's disk method)

7.1 Antibacterial Assessment by Quantitative Bacterial reduction Test (AATCC test method 100 - 2004):

Test Organism Used:

Escherichia coli ATCC 11229

Staphylococcus aureus ATCC 6538

Initial inoculums:

- E. coli – 2.7 X 10⁹ cfu/ml
- S. aureus – 2.6 X 10⁹ cfu/ml

•About 5.0 cm diameter of the treated fabric was taken and it was immersed in sterile AATCC broth with 0.1 ml inoculum of each culture (*Staphylococcus aureus* and *Escherichia coli*) and left overnight at 37 °C in shaker. Control was also maintained with untreated fabric.

- AATCC broth with the fabric was taken for appropriate dilutions.
- The broth was spread plated on AATCC agar plates.
- The plates were incubated at 37°C for 24 hrs.
- After incubation results were interpreted.

The percentage reduction of bacteria after incubation was calculated by the following formula

$$R (\%) = (B - A) \times 100 / B$$

Where A is the number of bacteria colonies from treated specimen after inoculation over 24 hour contact period and B is the number of bacteria colonies from untreated control specimen. Fig.1. shows the AATCC 100 test.



Fig 1
Analysis of Antibacterial activity of finished fabric by AATCC 100 test method

7.2 Contact Allergy testing

Method

Subjects tested were random volunteers representing three males and three females for the present study.

Principle

The fabrics were patched on the normal skin and observed for the specified period of time for the development of the symptoms leading to contact dermatitis allergy.

Procedure

Non hairy part of the skin of the subjects was selected. The surface of the skin was cleaned with cotton swabs dipped in clean water. The patches of the fabric sample were made and plastered on the surface of the cleaned skin. The site of patching was observed for any immediate allergic response. Observations were made up to 24 hours for the symptoms such as reddishness, rashes, irritations, etc. The time of observation may be extended for another 24 hours to confirm the effect. Fig 2. Shows the photo images of anti allergy nature of control and treated fabrics by contact allergy testing.



Fig 2. Photo for the analysis of anti allergy nature of treated fabrics by contact allergy testing

7.3 Fabric surface analysis tests:-

The confirmation of the presence of active components has been done using FTIR (Fourier Transform Infrared Spectroscopy) tester. The confirmation of the presence of active components has been done using SEM (Scanning Electron Microscope) tester.

7.4 Comfort property testing

The air permeability of the fabrics were carried out in KES Air-permeability tester which gives the resistance of the tested fabric to the passage of air using the ASTM D7-96 standard test method for air-permeability of textile fabrics. Water Absorbency Test (AATCC/ASTM TEST METHOD TS-018) method is used to measure the water absorbency of textiles by measuring the time it takes a drop of water placed on the fabric surface to be completely absorbed into the fabric samples are placed over the top of a beaker so that the centre is unsupported. A measured drop of water is placed on the fabric 1cm from the surface time is recorded until the water drops absorbs completely. Lee's disc method is used for measuring the thermal conductivity of the fabric. ASTM method E 96-80 test procedure is used for the measurement of water vapour permeability. The drapeability of the developed samples was tested with drape meter by using cusack drape test method.

8) Identification of best health care fabric sample based on antibacterial, surface characteristics and comfort property analysis

The best health care fabric sample to care against psoriasis was identified based on antibacterial, surface characteristics and comfort property analysis using t test.

IV.RESULTS AND DISCUSSION

A. Particle Size Analysis

The particle size analyzer test results (Fig.3) shows that the average nano particle size of the herbal extract found to be 756.2nm.



Fig 3. Size of the nano particle extract

B. Antibacterial assessment by quantitative bacterial reduction test (aattcc test method 100 - 2004)

The anti-bacterial test result of the treated fabrics is given bellow in the table III.

Table III. Assessment of anti microbial activity by AATCC 100 test method

Sample	Bacterial reduction (in %)	
	Staphylococcus aureus	Escherichia coli
100% organic cotton	100	100
100% bamboo	98	97
Cotton/ bamboo blend	99	100

From the test results, it is evident that the treated fabric samples have excellent antibacterial activity against both the test organisms.

C. Assessment of anti allergy nature of treated fabrics by contact allergy test

Fig.4 shows the contact allergy test results

Subjects	Control			Finished		
	100% Organic cotton	100% Bamboo	Cotton Bamboo	100% Organic cotton	100% Bamboo	Cotton Bamboo
Subject 01 (Male / 25 yr)	IR	-	IR	-	-	-
Subject 02 (Male / 32 yr)	IR	-	-	-	-	-
Subject 03 (Male / 30 yr)	-	+	-	-	-	-
Subject 04 (Female / 24 yr)	-	+	-	-	IR	-
Subject 05 (Female / 29 yr)	+	+	IR	IR	-	-
Subject 06 (Female / 30 yr)	IR	-	+	-	-	IR

Note:

- (IR) - Irritant reaction
- (-) - No irritant reaction
- (+) - Weak positive
- (++) - Strong positive

Fig 4. Contact Allergy Test results

From the above test result it is observed that the control samples showed weak positive to irritant reaction on the test subjects whereas treated sample showed no irritant reaction to irritant reaction. This clearly confirms that all the fabric samples do not cause any irritation to the people who are affected with psoriasis. This is very important result since the psoriasis got worsened due to the clothing irritation.

D. Evaluation of comfort properties

1) Evaluation of Air permeability Characteristics

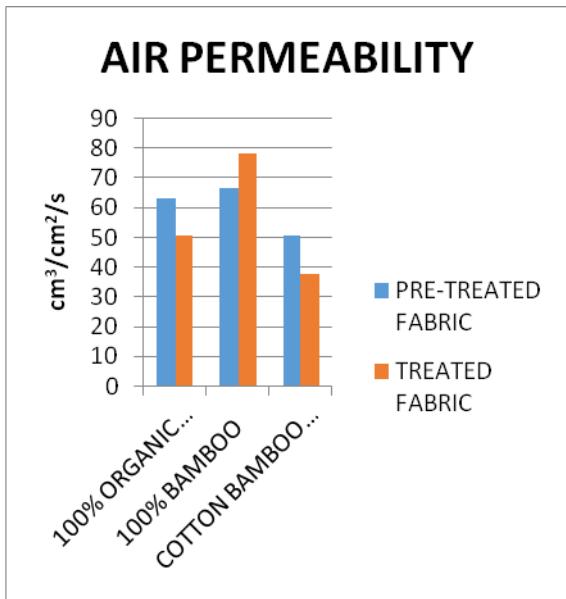


Fig 5. Analysis of air permeability test

From the Fig.5, when compared with all three fabrics, air permeability of 100% bamboo treated fabric is high. This property will help significantly in the textiles meant for skin disease psoriasis by providing cooling effect to the affected skin. This also helps to dry out the sweat emitting from the skin easily, which will give wearing comfort to the wearer.

2. Evaluation of Water Vapour Permeability Characteristics

The water vapor permeability results of the samples are presented in Fig.6.

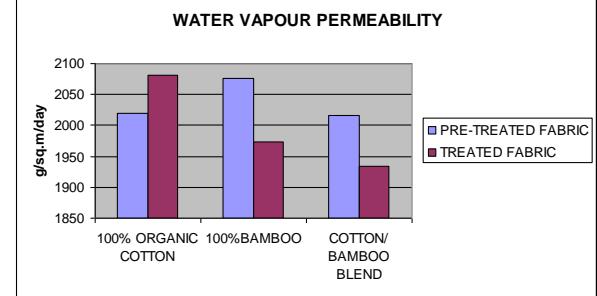


Fig 6. Analysis of water vapour permeability test

The results shows that water vapor permeability of 100% organic cotton treated fabric is high. This property will help significantly in the textiles meant for skin disease psoriasis. A fabric of low moisture vapor permeability is unable to pass sufficient perspiration and this lead to sweat accumulation in the clothing and hence discomfort.

3. Evaluation of Water Absorption Characteristics

The water absorption results of the samples are presented in Figure 7.

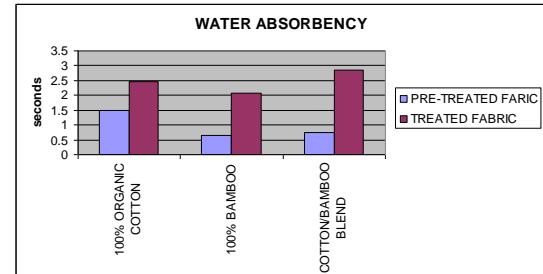


Fig 7. Analysis of water absorption test

The test results show that water absorbency of 100% bamboo treated fabric is good. The lower value of moisture absorbency helps to absorb the sweat/secretion from the skin of the people who are affected with psoriasis at the faster rate which will lead to wearing comfort to the patient.

4. Evaluation of Thermal Conductivity Characteristics

The thermal conductivity results of the samples are presented in the Figure 8.

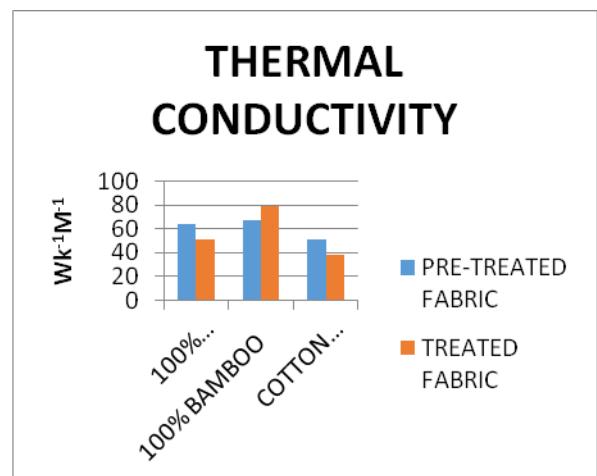


Figure 8. Analysis of thermal conductivity test

The test results shows that 100% bamboo treated fabric has high thermal conductivity. As the apparel has a higher part to play in the maintanence of heat balance as it modifies the heat loss from the skin surface at the same time has the secondary effect of altering the moisture loss from the skin. This result will help the psoriasis affected people to a great extent by providing thermal comfort.

5. Evaluation of Drapeability Characteristics

The drapeability results of the sample presented in Figure 9.

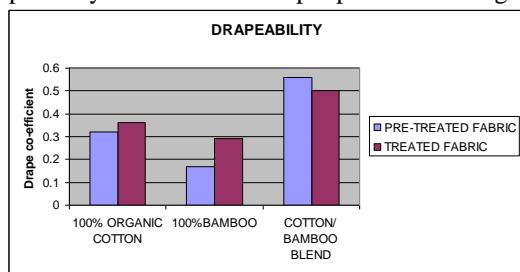


Figure 9. Analysis of drapeability test

The test results show that 100% bamboo treated fabric exhibited good drapeability characteristics. This property can be positively exploited in the development of health care apparel. Since the fabric respond easily to the psoriasis patient's body contour due to its good drapeability nature.

E. Identification of the best sample (Organic cotton Vs Bamboo) based on Comfort property analysis

Table IV. Identification of best sample based on t-test results

S.No	Particulars	T test result	Favour
1.	Air permeability	Insignificant	—
2.	Water vapor permeability	Significant	100% organic cotton
3.	Water absorbency	Significant	100% bamboo
4.	Thermal conductivity	Significant	100% bamboo
5.	Drapeability	Significant	100% bamboo

The table IV shows the t-test results for selecting the best among 100% organic cotton, 100% bamboo and bamboo/cotton blended treated fabrics. The test results show that 100% bamboo treated fabrics has good comfort characteristics.

F.Evaluation of fabric surface characteristics analysis

1) Fourier infrared spectroscopy test (FTIR)

The Fourier Infrared spectroscopy (FTIR) image of pre-treated and nano-encapsulated samples is given in figure 10, 11, 12, 13, 14 & 15. From the graph, it is clearly evident that the presence of active components in the herbal extracts used with the notice of additional peaks in the treated fabrics when compared with the pre-treated fabric sample peaks.

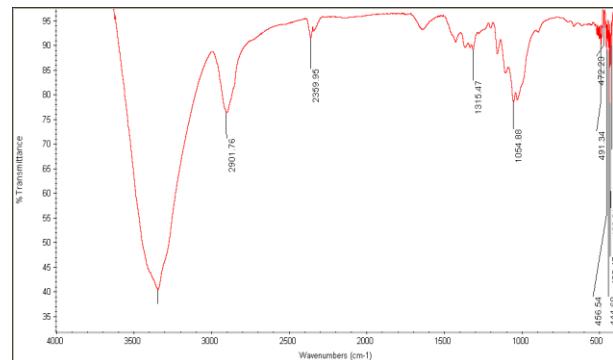


Figure 10. FTIR spectrum of pre-treated 100% organic cotton fabric

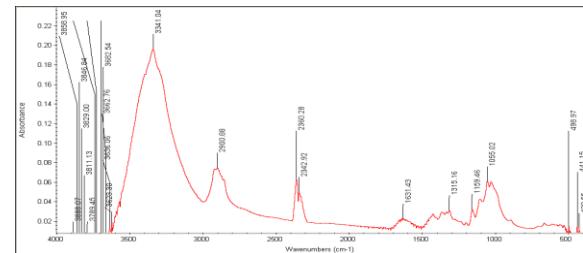


Figure 11. FTIR spectrum of nano-encapsulated 100% organic cotton fabric

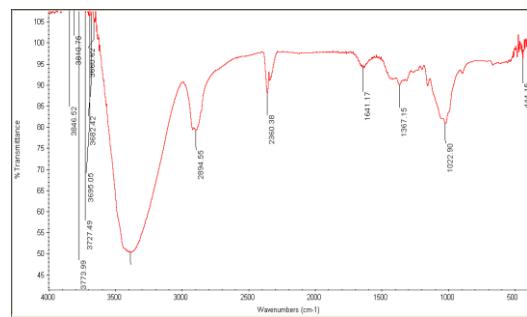


Figure 12. FTIR spectrum of pre-treated 100% bamboo fabric

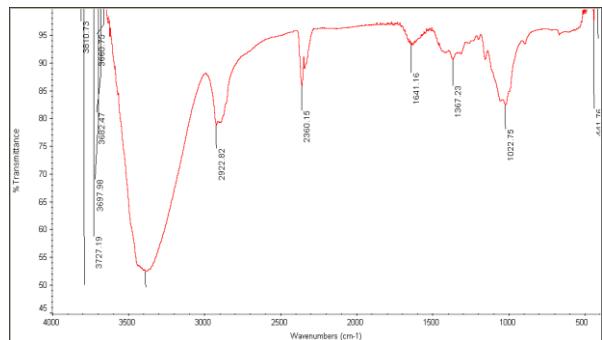


Figure 13. FTIR spectrum of nano-encapsulated 100% bamboo fabric

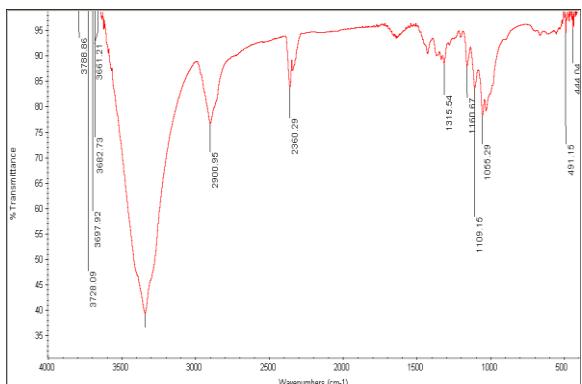


Figure 14. FTIR spectrum of pre-treated cotton/bamboo blend fabric

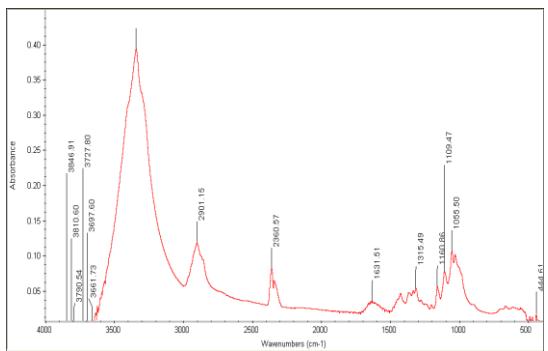


Figure 15. FTIR spectrum of nano-encapsulated cotton/bamboo blend fabric

2) Scanning electron microscopy test (SEM)

The scanning electron microscopy (SEM) images of the untreated and treated fabric samples from the photographs, it is clearly evident that the presence of nano-capsules firmly attached to the treated fabric samples as shown in the figures 16.a, 16.b, 17.a, 17.b, 18.a and 18.b.

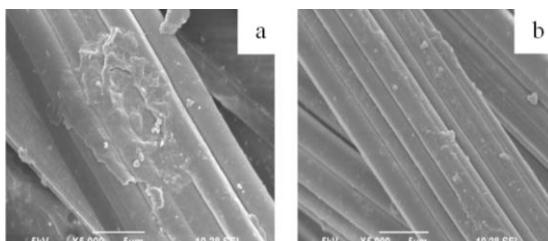


Fig 16.a SEM image of pre-treated 100% organic cotton Fabric.

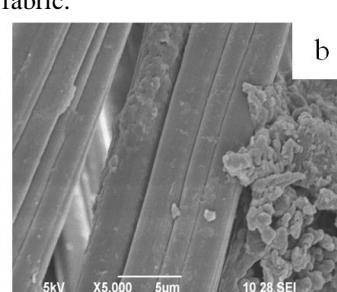


Fig 16.b SEM image of nano-encapsulated 100% organic cotton fabric.

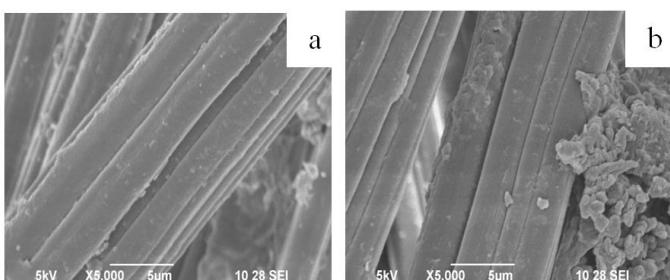


Fig 17.a SEM image of pre-treated 100% bamboo fabric
Fig 17.b. SEM image of nano-encapsulated 100% bamboo fabric

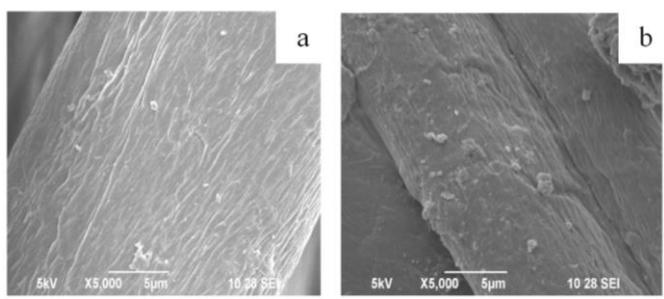


Fig 18.a
SEM image of pre-treated Cotton/bamboo blend fabric

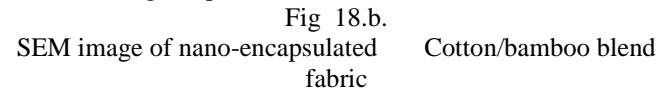


Fig 18.b.
SEM image of nano-encapsulated Cotton/bamboo blend fabric

V. conclusions

From the antibacterial test results, it is evident that all the developed nano-encapsulated fabric samples have excellent anti bacterial activity against both the test organisms. From the contact allergy testing-patch test, it is evident that the control sample showed weak positive to irritant reaction on the test subjects whereas treated samples showed no irritant reaction. This clearly confirms that all the fabric samples do not cause any irritation to the people who are affected with psoriasis. The comfort property test results analysis shows that among the three tested fabrics, nano-encapsulated 100% bamboo fabrics showed best results with regard to water absorbency, thermal conductivity and drapeability characteristics. In Fourier transform infrared spectroscopy analysis, the presence of active components has been confirmed. The scanning electron microscopy analysis also confirmed the presence of nano-capsules on the fabric structure. The best treated fabric was identified as 100% bamboo treated fabric based on all the test results and it is suitable for the people affected with psoriasis.

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