

# Design and Development of Shoe Insole for Diabetic Patients

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**Abstract:** In recent years, terms like ‘going green’ and ‘eco-friendly’ have become buzz words on talk shows, commercials and product making. Likewise we have brought our product under the shadow of eco-friendly and disposable. Our main product is shoe insole for diabetic patients. The shoe insole holds the natural products such as bamboo and chitosan. Bamboo fibre being a biodegradable textile material has many antibacterial qualities. Above that chitosan has both antibacterial and antimicrobial performance inhibiting bacteria’s growth. Bamboo fibre is converted into web using carding machine. The web obtained is fed for needle punching. The non-woven material is made to dry and taken out for testing. The specimen undergoes follows anti-bacterial test, wound pathogen test and the result gave good activity towards bacteria and organism like staphylococcus aureus, klebsiella and pseudomonas. Since it is a use and throw material, it need not have to support sufficient mechanical properties.

**Key words:** Antibacterial, Antimicrobial, Bamboo fibre, chitosan, diabetic patients, klebsiella, pseudomonas, shoe insole, staphylococcus aureus

## I. INTRODUCTION

### A. Bamboo fibre

Bamboo fibre is a natural textile made from the pulp of the bamboo grass. Fabric made with Bamboo fibre has been growing in popularity, because it has many unique properties and is more sustainable than most textile fibres. Bamboo fabric is light and strong, has excellent wicking properties, and is to some extent antibacterial. Generally bamboos are commonly used for furniture, construction, musical instruments and many more things. Bamboo is not only highly fashionable for decorative purposes but useful too. As it is a viable replacement for wood, in far Eastern countries, it is the primary building material [1,2]. The various advantage lies with bamboo has evolved it as a suitable textile grade material. Bamboo fabric is light & strong and has excellent wicking properties. Bamboo fabric is very soft and can be worn directly next to the skin. Many people who experience allergic reactions to other natural fibres, such as wool or hemp, do not complain of this issue with Bamboo. The fibre is naturally smooth and round without chemical treatment, meaning that there are no sharp spurs to irritate the skin. In Bamboo fabric, this translates to an excellent wicking ability that will pull moisture away from the skin, so that it can evaporate. Bamboo also has many antibacterial qualities, which Bamboo fabric is apparently able to retain, even through multiple washings, which helps in reducing the bacteria that thrive on clothing. It can also kill odour causing bacteria that live on human skin, making the wearer and his/her clothing smell sweeter. In addition, Bamboo fabric has insulating properties and will keep the wearer cooler in summer and warmer in winter. [3,4]

### B. Chitosan Powder:

Chitosan is gaining popularity as a textile fibre which can be specifically used for medical purposes. It is a unique material with certain special properties, preferred for medical usage. It has been found that wound dressings from chitosan can increase the rate of healing by 75%. Molecular structure of chitosan is very similar to chitin and cellulose. If chitosan really can prevent the fat absorption, it can also prevent the absorption of other fat-soluble substances and negative-charged

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substance (chitosan is positively-charged)[5]. Chitosan, the deacetylated derivative of chitin, is a natural D-glucosamine polymer that can be extracted from the shells of seafood such as prawns, crabs and lobsters. It can be used as a wound healing promotion agent and antimicrobial agent. Chitosan has enormous potential as therapeutic material due to its interesting features such as antimicrobial nature, scar prevention and biocompatibility[6,7]. Chitosan is impermeable to exogenous microorganism due to its top layer and inherent antimicrobial property of chitosan and show excellent oxygen permeability, controlled evaporative water loss and enhanced fluid drainage ability.[8]

### C. Diabetic Foot Ulcer:

A diabetic foot ulcer is an open sore or wound that most commonly occurs on the bottom of the foot in approximately 15% of patients with diabetes. Of those who develop a foot ulcer, approximately 6% will be hospitalised due to infection or other ulcer-related complication. It may take weeks or even several months for your foot ulcers to heal. Diabetic ulcers are often painless.[9] Nonwovens are typically manufactured by putting small fibres together in the form of a sheet or web similar to paper on a paper machine, and then binding them either mechanically as in the case of felt, by interlocking them with serrated needles such that the inter-fibre friction results in a stronger fabric, with an adhesive, or thermally by applying binder in the form of powder, paste, or polymer melt and melting the binder onto the web by increasing temperature.[10,17] Staphylococcus aureus, often referred to simply as “staph”, are bacteria commonly carried on the skin or in the nose of healthy people. Approximately 25% to 30% of the population is colonized (when bacteria are present but not causing an infection) in the nose with staph bacteria. Sometimes, staph can cause an infection. Staphylococcus bacteria are one of the most common causes of skin infections in United States. Most of these skin infections are minor (such as pimples and boils) and can be treated without antibiotics (also known as antimicrobials or antibacterial). However, staphylococcus bacteria also can cause serious infections (such as surgical wound infections, blood stream infections, and pneumonia).[11,12] Klebsiellapneumoniae is a gram negative, non-motile facultative anaerobe belonging to the Enterobacteriaceae family. It consists of straight rods 1 to 2 micrometres in length with a thick, surrounding capsule when cultured, this species produces a distinctive yeasty odour and bacterial colonies have a viscous/ mucoid appearance.[13,14] Pseudomonas is a gram- negative, aerobic coccobacillus bacterium with unipolar motility. An opportunistic human pathogen and also an opportunistic pathogen of plants. P.aeruginosa secretes a variety of pigments, including pyocyanin (blue-green), pyoverdine (yellow-green and fluorescent) and pyorubin (red-brown).[15,16]

## II. MATERIAL AND METHODS

### A. Web Preparation:

Every single lap is made by making use of the carding machine, weighing the fibre to 40gms. The weighed fibre is fed into the carding machine as required and finally a lap is formed. Likewise the necessary laps are developed.

### B. Needle Punching:

The bamboo lap is fed into the needle punching machine. The needles penetrate into the lap and a punching of lap occurs. Finally the needle punched non-woven material is produced.

### C. Chitosan Solution Preparation:

The solution is prepared based upon the material weight and also by varying the weight of the chitosan. Here citric acid used to dissolve the chitosan powder. In generally the material is weighed. According to the M:L ratio 1:20, the water, citric acid and the chitosan is taken as per the weight of the non-woven material. In another process, material weight is kept constant and the amount of chitosan powder is varied. Take a beaker; fill the required amount of water. Add the citric acid and allow it to dissolve in it. Then add the chitosan powder. Continuous stirring should be given to the solution, so that the chitosan can dissolve easily and hence the chitosan solution is prepared.

### D. Tray Technique:

Cut needle punched material to the required size and place in a plastic tray. Now take the solution and spread it evenly on the material. The material is left to dry at the room temperature for 48hrs.

### E. Testing:

#### Antibacterial Test

AATCC 147 parallel streak test method:-

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- To detect bacteriostatic activity on tensile materials.
- A loopful of inoculum is transferred to the surface of sterile agar plate in 5 streaks.
- Rectangular cut sample is placed transversely across streaks to ensure intimate contact with agar surface.
- Incubation period of 24-48 hours at body temperature.
- A clear area of interrupted growth underneath and along the sides of the test material indicates antibacterial activity.
- The parallel streak method has filled a need for a relatively quick and easily executed qualitative method to determine antibacterial activity of diffusible antimicrobial agents on treated textile materials.

AATCC method 100, antibacterial test on textile materials, is a quantitative procedure which is adequately sensitive but cumbersome time and screening tests. Therefore when the intent is to demonstrate bacteriostatic activity by the diffusion of the antibacterial agent through agar, method 147 fulfills this need. In the parallel streak method, the agar surface is inoculated making it easier to distinguish between the test organism and contaminant organism which may be present on the unsterilized specimen. The parallel streak method has proven effective over a number of years of use in providing evidence of antibacterial activity against positive and negative bacteria.

### Wound Pathogen Test:

#### Agar Diffusion Plate Test:

ENISO 20645 is essentially qualitative test method for determining the effect of antibacterial treatments applied to woven, knitted and other flat textiles. A minimum diffusion of the antibacterial into the test agar is necessary with the procedure. Standard conditions specify a contact time period of 18 to 24 hours using *Pseudomonas* and *Klebsiella*.

The antibacterial activity of the finished fabric was tested according to EN ISO 20645 against *Klebsiella* sp., and *Pseudomonas* sp., Nutrient agar plates were prepared by pouring 15 ml of media into sterile Petri dishes. The plates were allowed to solidify for 5 minutes and 0.1% inoculum was swabbed uniformly and allowed to dry for 5 minutes. The finished fabric with the diameter of  $2.0 \pm 0.1$  cm was placed on the surface of medium and the plates were kept for incubation at 37°C for 24 hours. At the end of incubation, the zone of inhibition formed around the fabric was measured in millimetres and recorded.

#### Water Absorption And Water Desorption Test:

The sample is cut into 50\*50 sq.mm. Initial weight is noted. The sample is then soaked in water with the help of a tray for about 6 hours. Then the sample is taken out and left on a blotted paper. The water is absorbed and later the sample is allowed for weighing as final weight. Again another sample is taken and soaked in water and kept still for 16 hours. The sample is allowed of weighing. The final weight is noted.

Water desorption/ water absorption = (Final weight – Initial weight)/ Final weight

## III. RESULT AND DISCUSSION

### A. Antibacterial Test:

AATCC 147 parallel streak test method:-

Table 4.1 Interpretation of Antibacterial Test

Sample	Anti-Bacterial Activity Against Staphylococcus Aureus (Zone Of Inhibition-Mm)
Needle punched Bamboo non-woven finished with chitosan	45

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Interpretation:

A clear area of interrupted growth underneath and along the sides of the test material indicates ANTI-BACTERIAL ACTIVITY. The table 4.1, figure 4.1 and figure 4.2 shows the antibacterial activity result, graphical representation of the result and sem image of the test respectively.

### Graphical Representation:

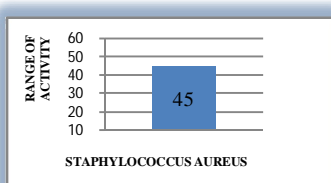


Fig 4.1 Grapical representation of antibacterial activity

### Sem Image of Anti-Bacterial Test on the Sample:

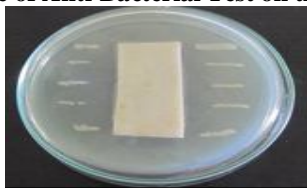


Fig 4.2 Sem image of anti bacterial test carried sample

**Table 4.2 Interpretation of anti-bacterial activity for the variables**

S.NO	SAMPLES	ANTIBACTERIAL ACTIVITY AGAINST STAPHYLOCOCCUS AUREUS(ZONE OF INHIBITION-mm)
1	Bamboo web finished with chitosan -1	40
2	Bamboo web finished with chitosan -2	42
3	Bamboo web finished with chitosan -3	43

### Variables:

Interpretation:

A clear area of interrupted growth underneath and along the sides of the test material indicate ANTI-BACTERIAL ACTIVITY .The table 4.2, figure 4.3, figure 4.4 shows the antibacterial activity result of three variables, graphical representation of those results and sem image of the tests respectively.

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### Graphical Representation:

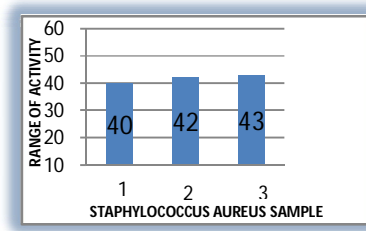


Fig 4.3 Graphical representation for anti-bacterial test

### SEM Image of Antibacterial Test Carried out in Variables:

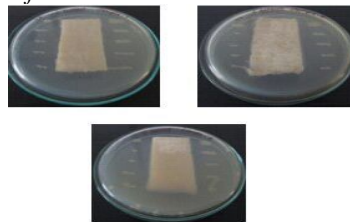


Fig 4.4 SEM image of anti-bacterial activity for variables

### Wound Pathogen Test:

#### Interpretation:

A clear area of interrupted growth underneath and along the sides of the test material indicates GOOD activity towards WOUND PATHOGENS. The table 4.3, figure 4.5, and figure 4.6 shows the result of wound pathogen test, graphical representation of the result, and sem image of the test respectively.

Table 4.3 Interpretation of wound pathogen test

S.No	Sample	Organisms	
		Klebsiella Sp.,	Pseudomonas Sp.,
1	Bamboo Web Finished With Chitosan	37	36

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### Graphical Representation:

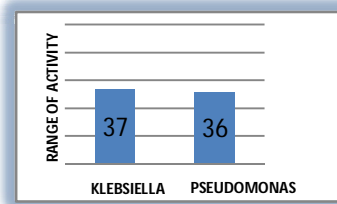


Fig 4.5 Graphical representation for wound pathogen test

### SEM Image of Wound Pathogen Test:

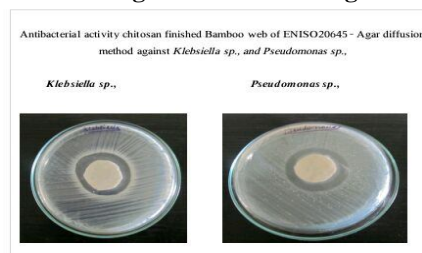


Fig 4.6 SEM image of wound pathogen test carried on the sample

### Mechanical Test:

Wet Tensile Strength Test:

Report:

Mean tensile strength (direction 1) - 0.12 Mps

Mean tensile strength (direction 2) - 0.64Mps

Average thickness of the specimen is 2.2 mm

### Graphical Representation:

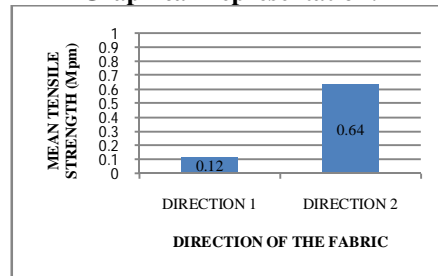


Fig 4.7 Graphical representation for wet tensile strength

### Water Absorption and Desorption Test:

Water desorption/ water absorption = (Final weight – Initial weight)/ Final weight

The figure 4.9 and figure 4.8 shows the water absorption and desorption result respectively.

Water absorption - 493.4%

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Water desorption - 85.2%

**Graphical Representation of Water Absorption:**

**Graphical Representation of Water Desorption:**

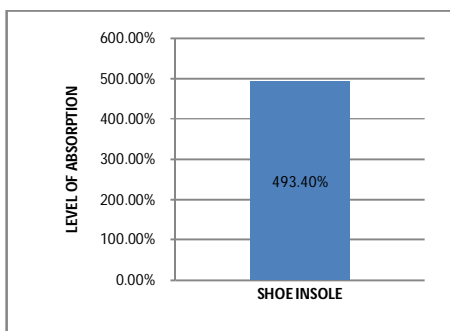


Fig 4.8 Graphical Representation for Water Absorption

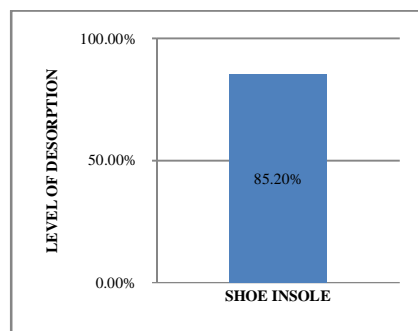


Fig 4.9 Graphical Representation of Water Desorption

**Flexing Index:**

**Procedure:**

The samples are cut into strips of 10mm each. One end of the sample is fixed, and other is allowed to get fixed to a swing. The pendulum is allowed to swing from one point to another, likewise at one point of time the material breaks. That point is noted in the instrument. The values are noted for about 30 cycles. The log value is found by comparing the norms. The values are noted.

**Report:**

Flexing index (Direction 1) - 2.8  
Flexing index (Direction 2) - 1.3

**Hence, the shoe insole proves the following result.**

- The given fabric sample have **GOOD** antibacterial activity against the test organism.
- The given samples have **GOOD** wound healing activity against the test organism.

## IV. CONCLUSION

The raw materials of our project itself are of great importance because both the materials are natural and have good anti-bacterial activity and hence the main objective of our project is achieved. The product was tested for antibacterial and wound pathogen test. Both the test gave good activity towards bacteria and organisms. Therefore it is proven that our diabetic shoe insole will heal the wound of foot ulcer. Even by reducing chitosan to some extent and not much, it is possible to heal the foot ulcer of the diabetic patients. In recent trends people are looking up for easy-go. This product all stands up in this way. This all adds up as **use and throw** and also **wound healing product**.

Since the diabetic patients are at high for subsequence ulceration, the use of special footwear to protect the feet is highly recommended. When wound prevails in diabetic patients, the time to heal the wound is long and hence to make it in a short period of time and good healing activity; we have proudly introduced our product as shoe insole for diabetic patients using bamboo fibre and chitosan powder.

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