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Sustainable Antibacterial Finish On Cotton Knitted Fabric By Using Eucalyptus

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Abstract

The textile industry has seen a growing demand for sustainable and functional fabrics, particularly those with antibacterial properties. Traditional antibacterial finishes often rely on synthetic chemicals, which pose environmental and health risks. This project explores the use of eucalyptus oil, a natural and renewable resource, to impart an eco-friendly, antibacterial finish on cotton knitted fabric. Eucalyptus oil is known for its antimicrobial properties, and its application in textile finishing offers a sustainable alternative to conventional chemical treatments. The project will focus on optimizing the process of applying eucalyptus oil to cotton knitted fabrics, ensuring durability and long-lasting antibacterial effects even after multiple washes. Such as tensile strength, softness, and color fastness, will be thoroughly assessed. This eco-friendly treatment not only aligns with the growing trend toward sustainability in the textile industry but also provides consumers with healthier, non-toxic textile options.

Key words: Antibacterial finish, Cotton, Durability, Eucalyptus, Knit fabric, Properties

1 Introduction

In recent years, the textile industries have taken initiative to develop innovative sustainable antibacterial finish. Fabric treated with an antibacterial finish offers an additional protection against bacteria [1-3]**.** These chemical finishes are designed to actively inhibit growth or eliminate bacteria. These functional materials are often beneficial to human health, which is an interesting research direction.

Textile materials are excellent media for growing microorganisms, especially those use hospitals, underwear, and sportswear, because of their high surface area of contact for bacteria. Hence, the increasing interest for the personal health and hygiene has created the necessity to improve the antibacterial properties of textiles [4-8].

Antibacterial textile with improved functionality finds the variety of application such as health and hygiene products, especially the garment worn close to the skin and several medical applications such as infection control and barrier material [9]. Although the synthetic antibacterial agents are very effective against a range of microbes and give a durable effect on textile. There is a great demand for antibacterial textile based on eco-friendly agents. Any antibacterial agent's treatments performed on a textile, besides being efficient against microorganisms, must be non-toxic to the consumer and the environment applicability without negative effects on the textile properties [10].

In textile this antibacterial finish place and role widely used in children's garments, inner wears, socks, medical textile and some other fields. Bacteria, either pathogenic or not, are normally found on human skin, nasal cavities, and other areas, such as the genital area. The negative role of microorganisms in the textiles leads the researchers to the development of textiles with antibacterial properties [11-13]. With this growth in health awareness, many people focused their attention one themselves about and protecting themselves from harmful pathogens. It soon became more vibrant for antibacterial finished textiles to protecttheuserfrombacteriaratherthansimplyprotectingthegarmentfromfiber degradation. Requirements for antimicrobial agents on textiles concern safety (producer and user), wash, and heat fastness and applicability without negative effects on the textile properties [14-16].

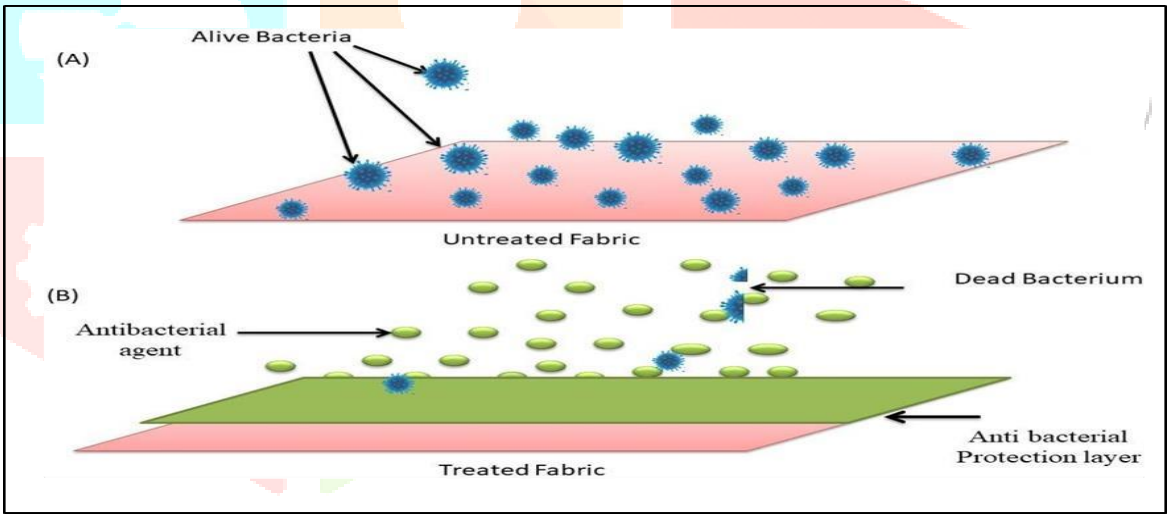


Figure1: Contact killing on antibacterial textile

Textile surface modification provides a way to impart new and diverse properties (such as antibacterial activity, self-decontamination, hydrophilicity, hydro phobicity, and biocompatibility) to textiles while retaining comfort and mechanical strength. However, textile surface modification often involved multi-step chemical treatments which could consume a large quantity of water and energy and consequently increase costs and environmental impacts [17,18]. For this reason, the textile industry is looking for eco-friendly surface modification process that can be carried out without toxic textile chemicals. Recently, the use of low-environmental impact technologies based on sustainable biopolymers presents an ovel possible a venue for larges development of functional textiles in a green sustainable approach. In specific textile biological functional materials are often beneficial to human health, which is an interesting research direction. It is a good choice to organically combine materials with superior functional characteristics and commercial textile to form products with excellent performance [19-23].

In our research we have developed a sustainable antibacterial finish from poly-saccharides like Chitosan combining with bio based material to give good antibacterial properties.

Objectives

a) To important bacterial finish on textile material which can be used for bacterial protection.

b) To obtain this antibacterial finish the textile material is treated with combination of Chitosan and eucalyptus oil,

c) To develop the antibacterial finished material which is bio-based, sustainable, economical and eco friendly.

2. Materials and methodology

The combination of eucalyptus oil and chitosan has been done for its potential antibacterial properties in textile applications. Eucalyptus oil is known for antibacterial effects, while chitosan, derived from chitin found in crustacean shells, possesses antibacterial and biocompatible properties. When applied to textile materials, the combination of eucalyptus oil and chitosan can provide an antibacterial finish. The eucalyptus oil acts as a natural anti- bacterial agent, inhibiting the growth of those bacteria on the fabric. Chitosan, on the other hand, enhances the durability and efficiency of the antibacterial finish. The combination has shown promise in various studies for its effectiveness against a wide range of bacteria including both gram positive and gram-negative strain. It has potential to be utilized in various textile applications where antibacterial properties are desired, such as medical textile, sportswear and other fabrics.

It is important to note that why this combination has shown potential, the specific method and formulization for applying eucalyptus oil and chitosan to a textile may vary depending on the desired outcome and the specific fabric type.

Materials used.

- Chitosan
- Dematerialized water
- Polysorbate
- Polyethylene
- 1,2,Octanediol
- Biobased binder
- Eucalyptus oil
- Acetic acid
- Isopropyl alcohol.

Preparation of different Prototypes

Prototype 1

- Take a 250mlbeaker and add 1 gm of Chitosan , then dissolve the Chitosan by using acidified dematerialized water and dissolve the solution properly.
- Afterproperdissolutionofchitosanaddanotheractiveingredienteucalyptusoil.
- Stirthesolutioninmagneticstirrerforcertainperiodoftimeandaddsurfactant.
- After that add polyethylene amine and stir the solution.
- After adding all the solvents, the solutions were stirred furthermore for proper emulsification, then Isopropyl Alcohol is added to get a clear solution with proper stirring as shown in Fig.4.

Prototype 2

- Take a 250mlbeakerandadd1gmofchitosan, then dissolve the Chitosan by using acidified dematerialized water and dissolve the solution properly.
- Afterproperdissolutionofchitosanandaddanotheractiveingredienteucalyptusoil.
- Stirthesolutioninmagneticstirrerforcertainperiodoftimeandaddsurfactant.
- After that add bio-based binder and stir the solution.
- After adding all the solvents, the solution was stirred furthermore for proper emulsification, then Iso propyl alcohol is added to get a clear solution with proper stirring as shown in Fig.

Prototype 3

- Take a 250 ml beaker and add 1 gm of Chitosan, then dissolve the Chitosan by using acidified dematerialized water and dissolve the solution properly.
- After proper dissolution of Chitosan and add another active ingredient eucalyptus oil Stir the solution for certain period of time and add surfactant.
- Add1-2Octanediolandstirthesolution.
- After adding all the solvents, the solution was stirred furthermore for proper emulsification, the Isopropyl alcohol is added to get a clear solution with proper stirring as shown in Fig.4.

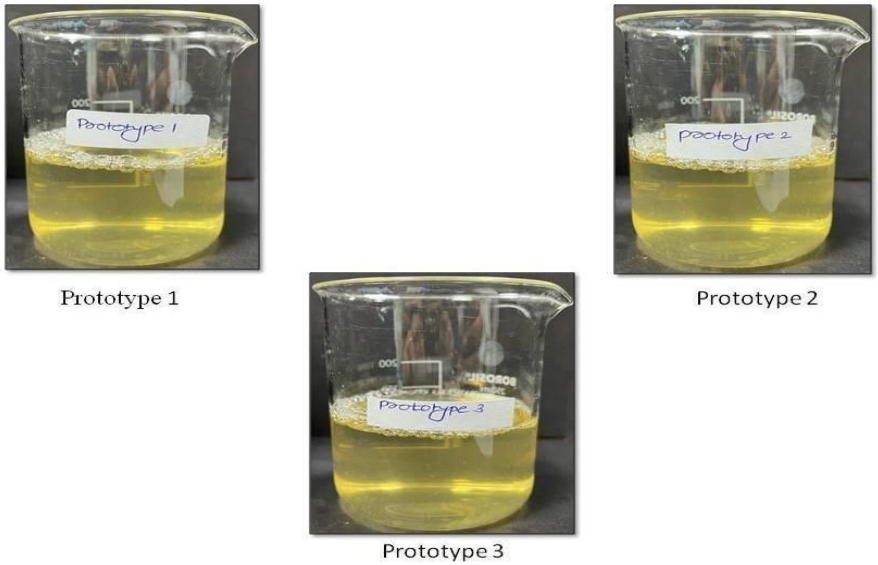


Figure5: Image of different R&D proto types

Stability Check

TheStabilityofformulatedprototypeischeckedbyvariousmethodsherewareusingfollowin g methods,

- Centrifuge Stability
- Heating Stability (or accelerated ageing) Shear Stability by using homogenizer
- Freeze thaw testing

By using centrifuge:

About6mlofsolutionistakeninacentrifugetubekeptinsidethecentrifugeand centrifugation carried out for 30 min at 3000 rpm. After 30 min samples are removedfromcentrifugemachinetocheckisthereanyphaseseparationoccurred or not. In our prototypes i.e., prototype 1, 2 & 3 no phase separation

Occurred as shown in Fig.5: All prototypes are centrifuges table.

Fig.6: All prototypes are centrifuges table.

Check heating stability by using Incubator:

Formulated prototypes are kept in a Incubator at 50°C to check its stability at higher temperature (accelerated ageing condition), all the proto types kept for high temperature for 7 days and there is no phase separation occur and all ares table as shown in Fig. 6.

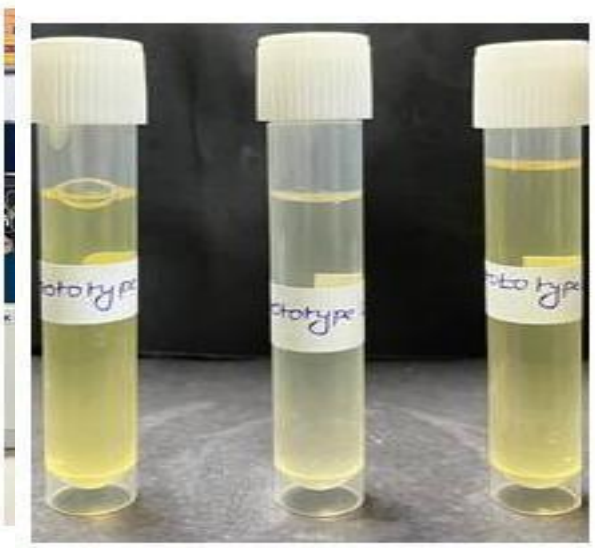


Figure 7 incubator

Shear Stability by using homogenizer:

Bath and shear stability is checked at 3% padding dosage of all the samples at 3000rpmandbathpHwasmaintainedinbetween5.5-6.5.to check any instability occurred during the bath preparation and after shearing of application bath. All the samples are stable in this process as shown in Fig.7.

Figure8: proto types after 7 days

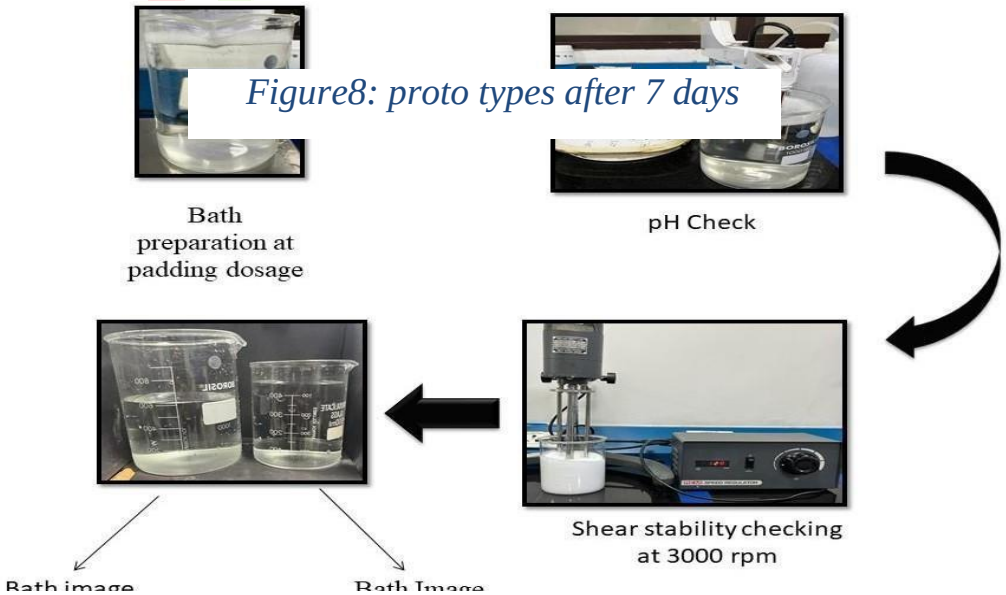
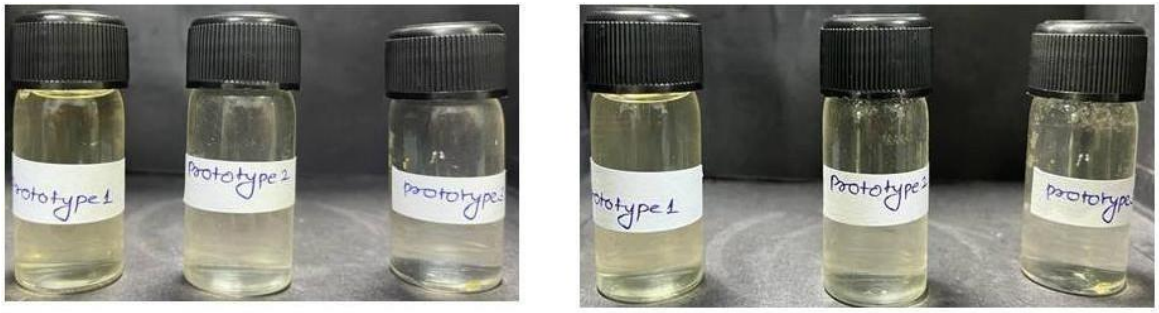


Figure8: Bath preparation and shear stability process

Freeze thaw method:

In freeze thaw process, samples were kept in freeze for 24hours freezing temperature after 24 hrs. they were removed and kept at room temperature to check if there were any phase separation occurred or not. This process was carried out in three cycles to check the product's stability. Our all the prototypes were found to be stable in this process as shown in Fig.8.

Figure9: Image of proto type samples before and after Freeze Thaw test



Before After

Application on fabric

Use a sustainable detergent or cleaning method based on the fabric type. After cleaning, rinse the fabric thoroughly to remove any residue detergent. Then, dry the fabric completely before proceeding with the antibacterial finishing application. Choose appropriate antibacterial agent for the desired finish.

Application procedure

The process of applying eucalyptus oil and chitosan on textile material for an antibacterial finish can involve several methods, here are a few commonly used methods,

- Pad dry method.
- Spray method.
- Exhaustion method
- Layer by layer method

These methods are just a few examples and there may be other variation or combinations depending on the specific requirements of textile material. For our antibacterial finish we are doing pad dry method.

Pad- dry

- Inthismethodthetextilematerialwaspaddedbyusingpaddingmanglewith R&D prototypes at 2% and 3% padding dosage.
- The excess solution was squeezed.
- The fabric was then dried by line dry.
- All the padding machine specification is mentionedinaTable3.1andpadding machine schematic diagram shown in Fig.9.

Table1 Specification of Padding machine

Machine Specifications	
Pressure	2.05psi
Speed	200m/min
Temperature	130°C
StenterSpeed	65.3m/min
Time	2min

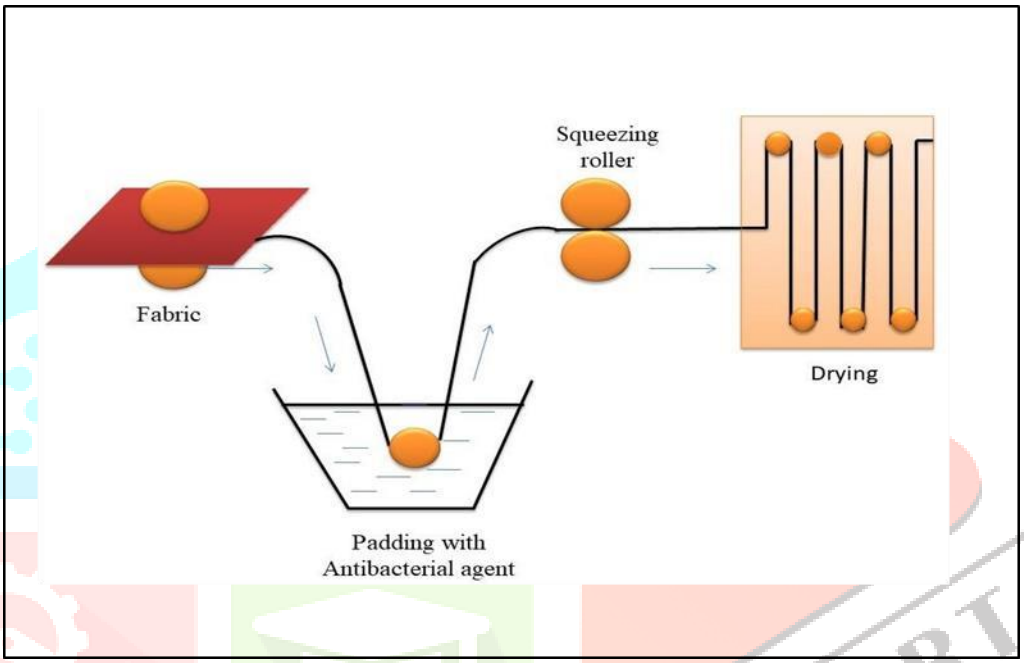


Figure10: Schematic of pad dry process

Testing parameters

- Antibacterial Test (AATCC147)
- Coffee test
- Milk test
- Wash Fastness

Results and discussion

- **Reduction in Chemical Usage**: One of the most significant outcomes of this project is the reduction of harmful synthetic chemicals in textile processing. Eucalyptus oil, as a natural antimicrobial agent, eliminates the need for traditional, potentially toxic antibacterial finishes like silver nano particles, triclosan, or formaldehyde-based treatments. This shift will contribute to lower environmental toxicity and reduced pollution associated with chemical runoff.

- **Biodegradability and Sustainability**: Eucalyptus oil is biodegradable and eco-friendly, ensuring that fabrics treated with this oil will break down naturally, avoiding long-term environmental harm. Unlike some synthetic finishes, eucalyptus oil won't contribute to non-biodegradable waste in landfills or water bodies, supporting a more circular, sustainable textile industry.
- **Support for Sustainable Agriculture**: Eucalyptus trees are fast-growing, require minimal water, and thrive in a variety of climates, making them a renewable resource. The use of eucalyptus oil will encourage the use of sustainably grown crops in the textile industry, promoting sustainable agricultural practices.

Conclusion

Recently, people are sensitive about healthy living and preferring healthy products in all areas including the textile goods. So it is thought that antibacterial textile products will be in demand in this context. For this aim different chemicals can be consumed in the textile industry. But different studies on the use of some different industrial crops have exhibited exciting results. In this study, beyond the known industrial crops and herbal wastes, dried and ground eucalyptus leaves were extracted and used in finishing of wool to color and gain an antibacterial activity. In the finishing process, the liquor ratio was chosen as 1:40 and experiments were carried out with and without mordants. After finishing processes, the samples were evaluated in terms of obtained colors (CIE L*a*b* values) and antibacterial activities against *Staphylococcus aureus* and *Escherichia coli* bacteria. Meanwhile, FT-IR and ICP-MS analysis, color fastness, and SEM images of the finished samples were also examined. As a result of these processes, it has been determined that wool fibers can gain antibacterial activities by using eucalyptus leaves and can be colored with this herbal waste. By the addition of mordants, the colors have differed and fabrics gained antibacterial activity against *E. coli* as well.

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