DEVELOPMENT OF ANTIMICROBIAL FINISHED FLAME-RETARDANT TEXTILES MATERIALS

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ABSTRACT

Trevira CS fabrics are treated with various antimicrobial agents viz., Eucalyptus Oil, Sanitized (T-99), Neem activated charcoal and Bamboo activated charcoal in order to study their antimicrobial finishing effect on flame-retardant properties. The fabric samples have been tested for its bactericidal activity using Nutrient Agar Diffusion Test method. It is found that Trevira CS fabrics treated with Eucalyptus Oil, Neem and Bamboo activated charcoals exhibit good antimicrobial resistance against E.coli, B.subtilis and S.aureus. The Trevira CS fabric treated with Sanitized (T-99) exhibits highest zone of inhibition as compared to other antimicrobial agent treated fabrics.

KEYWORDS: Eucalyptus Oil, Neem activated charcoals, Bamboo activated charcoals, Sanitized (T-99) and Trevira antimicrobial fabrics.

1. INTRODUCTION

Textile goods, especially made from natural Fibres, provide an excellent environment for microorganisms to grow, because of their large surface area and ability to retain moisture. With the growing public health awareness of the pathogenic effects, malodor and stain formations caused by microorganisms, there is an increasing need for antibacterial materials in many application areas like medical devices, health care, hygienic application, water purification systems, hospital, dental surgery equipment, textiles, food packaging, and storage [26].

Microbes could survive on fabric materials for more than 90 days. Few studies have examined the viability of gram-positive bacteria on fabrics, and those that have tested survival of staphylococci primarily on cotton [3]. As a means to reduce bacterial inhabitants in textile materials and possible to reduce infections caused by the textile materials, utilization of antimicrobial textiles is considered to be a potential solution [26]. Bacteria though does not damage the fibres, but can produce some fibre damage, unpleasant odours and a slick, slimy feel. Often, fungi and bacteria are both present on the fabric in a symbiotic relationship [10,4].

The spread of drug resistant microbial pathogens is one of the most serious threats to successful treatment of infectious diseases [23]. Escherichia coli, Bacillus subtilis and Staphylococcus aureus are the three opportunistic pathogens that cause severe, life-threatening infections in immune compromised patients. Escherichia coli (E. coli) and Staphylococcus aureus (S. aureus) are two opportunistic pathogens that cause severe and life-threatening infections in immunocompromised patients [14,17]. Several studies have documented increasing resistance rates in B.subtilis, S. aureus and E. coli to antibiotics [2,8,6,12,15,22].

Antimicrobials are protective agents that being bacteriostatic, bactericidal, fungistatic and fungicidal, also offer special protection against the various forms of textile rotting [26]. In recent years, antimicrobial treatment of textiles has become extremely important in the production of protective and technical textile materials. The number of different antimicrobial agents suitable for textile application available in the market has increased dramatically. Textile goods, especially those made from natural fibres, provide an excellent environment for microorganisms to grow, because of their large surface area and ability to retain moisture [10].

The Silica ammonium compound (Sanitized® - T9919) is unique in this group of active substances and the only one capable of a wash-resistant application on synthetic fibres and sustainably protects heavily used industrial articles and textiles. Quality and functionality are improved from the start, which makes them more attractive in the market. Silica ammonium compound makes the fabrics more elastic, tear-resistant and free from bacteria, fungi, algae and mildew, which hinders the disintegration of the material throughout its entire useful life and has strong effect on the functionality. Technical materials, which are damaged through bio-film build-up and the growth of algae, are weak and cannot function properly. Silica ammonium compound sustainably hinders the emergence and spread of damaging germs and provides lasting protection for the articles [11].

Bamboo charcoal (BC) has become popular recently due to its excellent characteristics of absorption, moisture regulation, anti-bacterial property, deodorization property, and generation of far infrared ray and negative ions [19]. Bamboo activated charcoal can also produce infrared rays suitable for absorption by the human body, thereby keeping the body warm and accelerating blood circulation [29]. Further, bamboo activated charcoal increases the number of negative ions, which are beneficial to human health and can refresh the air [1,21]. Neem is considered to be a part of India’s genetic diversity[25]. The Neem tree is the most researched tree in the world and is said to be the most promising tree of the 21st century.

In this study, Bamboo activated charcoal [7], Neem activated charcoal [28], Eucalyptus oil [24] and silica ammonium compound (Sanitized T-9919) [11] are used as antimicrobial finishes. The antimicrobial activity of Neem and Bamboo Activated Charcoal, Resins (Sanitized® T-9919) and Eucalyptus oil in treated samples are analysed.
2. MATERIALS AND METHODS
2.1 Fabric Production
To characterise the antimicrobial properties of the fabrics, 30 Ne Trevira CS Plain Jersey fabrics are used for the analysis of antimicrobial activity of the inherent flame-retardant fabrics [5]. The fabrics are knitted separately on 16" diameter Knitting Machine (PMW make). Sample single jersey fabrics are produced using a 24- gauge cylinder with 1200 needles and a positive feeder. The fabric produced has the following structural parameters (Table 1).

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Fabric Description</th>
<th>Courses per inch (CPI)</th>
<th>Wades per inch (WPI)</th>
<th>Areal Density (g/m²)</th>
<th>Fabric Thickness (mm)</th>
<th>Fabric Thickness at Maximum Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trevira CS (Ring Span Yarn Fabric)</td>
<td>50</td>
<td>34</td>
<td>152</td>
<td>0.817</td>
<td>0.494</td>
</tr>
</tbody>
</table>

2.2 Recipes for Imparting Fabric with Antimicrobial Finish
2.2.1 Treating knitted fabrics with Bamboo activated charcoal
1. Weight of the fabric : 6.505 grams
2. Material to Liquor ratio : 1:20
3. Amount of water : 130.1 ml
4. Bamboo Activated charcoal : 0.95grams
5. Ammonia : 1.15ml
6. Ethyl alcohol : 1.5 ml
7. Dispersing agent : 1.75ml
The fabric is treated with Bamboo Activated Charcoal using Padding Mangle and dried at 30°C.

2.2.2 Treating knitted fabrics with Neem activated charcoal
1. Weight of the fabric : 6.5 grams
2. Material to Liquor ratio : 1:20
3. Amount of water : 130 ml
4. Neem Activated charcoal : 1.25grams
5. Ammonia : 0.75ml
6. Ethyl alcohol : 1.2ml
7. Dispersing agent : 1.45ml
The fabric is treated with Neem Activated Charcoal using Padding Mangle and dried at 0°C.

2.2.3 Treating knitted fabrics with Eucalyptus Oil
1. Eucalyptus oil : 30% own
2. Binder : 4% own
3. Soap : 4% own
Fibres are treated with Eucalyptus oil using Padding Mangle and dried at 30°C.

2.2.4 Treating knitted fabrics with Silica Ammonium compound (Sanitized® T-9919)
1. Silica Ammonium Compound : 80 gpl
2. Binder : 2 gpl
Fibres are treated with Silica Ammonium Compound using Padding Mangle and dried at 80°C. Cured at 130°C

2.3 Characteristics of Antimicrobial Treated Fabrics
2.3.1 Agar diffusion method
Agar Diffusion Test is a preliminary test to detect the diffusive antimicrobial finish. It is not suitable for non-diffusive finishes and textile materials other than fabrics. The Agar Diffusion Tests are included in AATCC 147-2004 (American Association of Textile Chemists and Colorists), JIS L 1902-2002 (Japanese Industrial Standards) and SN 195920- 1992 (Swiss Norm) [16]. They are only qualitative, but are simple to perform and are most suitable when a large number of samples are to be screened for the presence of antimicrobial activity.

Pure culture of Escherichia coli (MTCC 443), Bacillus subtilis (MTCC 121) and Staphylococcus aureus (MTCC 96) were obtained from Institute of Microbial Technology, Chandigarh, India. The pure bacterial cultures were maintained on nutrient agar medium. Each bacterial culture was further maintained by subculturing regularly on the same medium and stored at 4°C before use in experiments.

Bacterial cells are inoculated on nutrient agar plates over which textile samples are laid for intimate contact. The cultures are streaked on sterile nutrient agar plates and kept in an Incubator for 24 hours at 37°C. Inoculum is prepared by growing the pure bacterial culture in nutrient broth overnight at 37°C. A fabric of 5mm diameter is sterilized. The test microorganisms are transferred from nutrient broth to sterile Hivg Nutrient agar plates with the help of sterile fabric swabs. Using an ethanol dipped and flamed forceps, the fabric is aseptically placed over the Hivg Nutrient agar plates seeded with the test microorganisms in triplicate. Another test is carried out without sterilizing the fabric. The Petri plates are incubated at 37°C for 24 hours and at the end of 24 hours the diameter of the resulting zone of inhibition is measured and the average values are recorded [9,13].

3 RESULTS AND DISCUSSIONS
Antimicrobial activity of resins (Sanitized® T-9919), Bamboo activated charcoal, Neem activated charcoal, and Eucalyptus oil treated samples are tested and their results are observed and tabulated.

From the Figures 1 to 9 the Sanitized® T-9919 treated samples show better results against both the gram positive and gram negative bacteria. It is attributed to the presence of Silica ammonium compound, an excellent antibacterial resource [11]. Hence, any combination of silica based compound of Sanitized® T-9919 samples shows good zones of inhibitions than the other antimicrobial agents. Further, it is also observed that after 15 washes the samples show good resistance against the gram positive and negative bacteria. This is clearly understood from Figures 3, 6 and 9. It is also understood that there is a reduction in the antimicrobial activity when the number of washes increases over the samples. It is clearly proved through the Coefficient of Determination shown in Figures 37 to 39.
On comparing the Sanitized® T-9919 treated sample for its antimicrobial activity of *S. aureus*, *B. subtilis* and *E. coli*, it was found that Sanitized® T-9919 has more antibacterial activity on *E. coli*

**Washes**

The samples treated with Eucalyptus oil also shows heat zone of inhibition. But it is observed from Figures 10-18 that is totally different after 10 to 15 washes. The antimicrobial behaviour of the Eucalyptus oil is attributed to the presence of Eucalyptol (1, 8-cineole) an active ingredient of the Eucalyptus oil.

It is also observed that this compound is highly responsible for its various pharmacological actions. Pharmacopoeia grade dried Eucalyptus leaf must contain at least 2.0% (v/m) volatile oil, composed mainly of 1, 8-cineole. The Eucalyptus oil has traditionally used in Ayurveda as an antiseptic and for respiratory tract infections.

Due to the volatile nature of Eucalyptus oil, the antimicrobial activity of the treated materials varies and there is a reduction in the fragrance level of the material. Because of its volatile nature, it goes off when the material undergoes washes and is subjected to heat environment. The performance of the fabrics treated Eucalyptus oil is depicted in Figures 37 to 39.

The Bamboo activated charcoal treated sample shows a good zone of inhibition. It is clearly observed from the Figure 19 to 27, the influence of extraction on the antibacterial properties of the natural Bamboo may be attributed to a few reasons. Firstly, the removal of some natural Bamboo extracts, such as carbohydrates and inorganic salts (which are microbial growth nutrients) (Higuchi 1987), could help slow bacterial growth and improve the microbial resistance. Secondly, the extracts may contain some antibacterial or antifungal components, and the reduction of the extracts may decrease the microbial resistance of the natural Bamboo at the same time.

Finally, changes in chemical composition could affect bacterial growth (Sun et al. 2006). Therefore, it can be inferred that the combination of these three aspects has led to the influence of extraction on the microbial resistance and antimicrobial properties of the natural Bamboo. The above facts can be clearly understood from Figures 19 to 27.

Figures 28 to 36 show the antimicrobial activity of the Neem activated charcoal treated Trevira CS fabrics. It is well-known that Neem, one of the most widely researched tropical trees is the source of therapeutic agents. The chemical composition of Neem extract has been analysed twenty years earlier. Many active components of Neem, Azadirachtin, Salannin, Meliantriol, or Nimbin etc., have been identified, and the most active ingredient is reported as Azadirachtin (Koul et al. 1990), which acts as a medicinal component in name.

As seen from Figures 1 to 36, the results of the study reveal that the Sanitized T-99 shows better results against the gram negative and gram positive bacteria followed by Bamboo activated charcoal, Neem activated charcoal and Eucalyptus oil. But when the test is performed after 10 and 15 washes, these samples show slight variation in their results. Further, the activated charcoal of Bamboo and Neem describe a-graphite like structure with random translation of layer planes along the axis and rotation of layer planes about the c-axis. The interlayer spacing in a turbo-stratic structure, which is larger than the spacing in a graphite single crystal.
Figure 37 Antimicrobial activity of study subjects on S.aureus

Figure 38 Antimicrobial activity of study subjects on B.subtilis
When the samples are treated with activated carbon, the porous structure of the charcoal starts to penetrate inside to the core of the fabric and it influences the anti-microbial ability. Similarly, surface roughness of the samples plays a major role in antimicrobial activity. The sample treated with resin has a higher zone of inhibition than other samples. It is also observed that the wash-ability of the samples after washing exhibit some antimicrobial behaviour with a zone of inhibition. Figures 37 to 39 represent the decay in the antimicrobial activity of these samples and the statistical analysis proves that the decay in the antimicrobial activity of fabrics increases when the numbers of washes increase.

In case of *S. aureus*, the plotting of Zone of Inhibition against number of washes exhibit power law functions of antimicrobial activity. But in case of the *B. subtilis*, Zone of Inhibition exhibits linear law of the functions of antimicrobial activity. When *S. aureus* and *B. subtilis* are compared with *E. coli* it depicts a different phenomena for all the four antimicrobial agents.

In case of Bamboo activated charcoal and Eucalyptus oil treated samples, the antimicrobial activity is power law of function against its wash fastness. But the same is not the case in Sanitized® T-9919 and Neem activated charcoal. The Sanitized® T-9919 treated sample exhibits antimicrobial activity as linear law of function against the wash fastness and Neem activated charcoal treated sample exhibits antimicrobial activity as the exponential law of function against the wash fastness.

### 4 CONCLUSIONS

The following conclusions are drawn from this research work:

The samples treated with Sanitized® T-9919 show higher level of antimicrobial activity. The resin treated samples showed good results with gram positive and gram negative bacterium. The resin treated samples have exhibited good results even after 15 washes when compared to other samples. Samples treated with Eucalyptus oil exhibit higher zone of inhibition before washing. Samples treated with Eucalyptus oil show reduction in a zone of inhibition after 10 and 15 washes. It is attributed to reduction in fragrance level. Neem activated charcoal and Bamboo activated charcoal treated samples exhibit good zone of inhibition. The zone of inhibition remains same after 10 and 15 after washes. The zone of inhibition of *S. aureus* is lower when compared to the *E. coli* and *B. subtilis*.

### REFERENCES


