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Studies on odor retention and antibacterial efficacy of non woven fabrics for technical textile applications

M. Parthiban, M.R. Srikrishnan and S. Viju

Dept. of Fashion Technology, PSG College of Technology, Coimbatore, (TN) - India

Abstract

In order to impart barrier property against microorganisms and control over the odor for corn foot treatment, three samples of 20/80 % polyester/viscose needle punched non woven fabric was treated with three different concentrations of *Aloe vera* & silver-nano solutions using pad- dry- cure method respectively. The samples were first treated separately with *Aloe vera* & silver-nano respectively and further treated with dual combination in a single bath. The treated samples were assessed for the antibacterial efficacy against *Staphylococcus aureus* and *E-coli* and the odor retention property was also analyzed. Samples treated with *Aloe vera* alone showed very low reduction rate in the number of bacterial colonies and exhibit high odor resistance. The samples treated with nano silver alone showed high reduction rate in number of bacterial colonies but showing low odor resistance. Dual finished sample treated with 100% conc. of *Aloe vera* and 7% conc. of nano silver showed higher reduction rate in number of bacterial colonies and having good odor resistance.

Key-Words: *Aloe vera*, Antibacterial efficacy, Finishing, Non woven, Silver-nano & odor retention

Introduction

Corns and callus are one of the most common problems seen by Podiatrists. They can occur on any part of the foot and vary in symptoms from a mild callus under the foot, to an infected ulcer that can develop under a corn on a toe^[1]. Corns appear as a horny thickening of the skin on the toes. This thickening appears as a cone shaped mass pointing down into the skin. A recommended ayurvedic remedy is the nightly application of a paste made by *Aloe vera*. In the initial stage of corn foot microbial attack will be maximum^[2]. The bacteria and fungi and their decomposition products cause infections and unpleasant odor. Anti microbial finish is a recent innovation in finishes. The consumers are now increasingly aware of the hygienic life style and there is a necessity and expectation for a wide range of textile products finished with antimicrobial properties^[3]. This finish prevents the growth of bacteria and products finished in it have been proved environment friendly and health protecting, preventing diseases. It also prevents garments from unpleasant odor.

The antimicrobial agents can be applied to the textile substrates by exhaust, pad-dry-cure, coating, spray and foam techniques^[4]. It's actually nano-silver used as an antimicrobial. That is silver that has been reduced to particles measured in billionths of a metre. It has effective anti microbial property due to the reason that remarkable and broad-spectrum sterilization can kill more than 650 disease-causing bacillus. Its antimicrobial rate is 99.99%.^[5] Several researches have used anti microbial finishes to provide fabrics with barriers against micro organisms and odor^[6]. We therefore undertook this project work to study the effect of dual functional finishing on non woven insole for corn foot treatment^[7, 8].

Material and Methods

A needle punched non woven fabric was sourced from local market with the following specifications listed in Table 1.

Finishing treatment

Three samples of the above specified non woven fabric were prepared and used for the study. The samples are Sample1 (*Aloe vera* treated), Sample 2 (Nanosilver treated) and Sample3 (Dual finished) respectively and the test results are compared.

To impart the odor retention property, the samples were padded through different concentration of bath

*** Corresponding Author**

E.mail: parthi_mtech@yahoo.com

Tel.: 0422-4344777, **Fax. :**0422-2573833

50%, 75% & 100% *Aloe vera* with a binder solution for half an hour, MLR- 1:10 at 50°C, dried at 90° C, cured at 120°C for 3 min respectively using pad-dry-cure method. To impart the antimicrobial finish, the samples were padded through different concentration of baths 3%, 5% & 7% silver-nano and ethanol solution, MLR- 1:10 for half an hour at 50°-60° C, dried at 90° C and cured at 120° C for 3 min respectively using pad-dry-cure method. For the dual finish, the specimens are pretreated with *Aloe vera* and then treated with silver-nano using pad dry cure method.

Table :1 Properties of non-woven fabric

Fabric particulars	Properties
Composition	20%Polyester/80% Viscose fibre with 26 gsm medical film
Color	White shade
Finish	One side thermally bonded with a medical film
Area density	360
Thickness	2.51
Bending modulus	9.6

Testing

Antimicrobial testing (AATCC 6358)

The anti microbial activity of the samples was evaluated quantitatively .The shake flask method, a standard test method, was used to measure the reduction rate in number of bacterial colonies formed and provided our quantitative data. *Staphylococcus aureus*, AATCC 6358, a gram positive bacterium, was the testing bacterium. In this procedure, a ± 0.1 g sample was dipped into a test tube containing *Staphylococcus aureus* culture solution in which the bacteria concentration was $1.5-3.0 \times 10^4$ /ml .The test tube was shaken at 35°C for 1 hour on a rotary shaker at 100rpm, and 1:100 dilutions of the test solution were made. One millimeter of the dilute test solution was poured onto TGE agar broth, and when this had been incubated at 35°C for 24 hours, the number of bacterial colonies in the agar broth was counted. The reduction rate in the number of bacterial colonies was calculated using the following equation:

$$\text{Reduction rate in number of colonies (\%)} = \frac{(A-B)}{A} \times 100$$

Where A=number of bacterial colonies before shaking and B=number of bacterial colonies after 1 hour shaking.

Odor absorption (Petri dish method)

Fabric specimens were uncovered for approximately 12 hours to allow any residual moisture retained from participants sweat or the outside environment to dissipate on the first night following collection. An hour prior to sensory analysis, fabric specimens were placed in a glass vessel (150 ml volume) and a glass Petri dish placed over the mouth of the vessel to contain the volatile compounds. Sensory analysis was conducted at 1 day (between 16–22 hours), 7 days and 28 days following removal of the fabric specimens from the body. The same group of fabric specimens was used during each of the three time periods. Each specimen was returned to its allocated Petri dish and stored with the lid on until required for further sensor. Thirteen assessors participated, each of whom had earlier shown good reliability and discrimination. The line scale method was used as previously described [26], with test samples assessed in two groups of ten. A control sample (samples are stored at either 40 % or 65 % R.H.) was always presented as the first sample and the order of presentation of the following specimens was based on the 18- treatment Williams' design to reduce order effects. Odor assessment was conducted in accordance with relevant ISO standards at a temperature and humidity range of 22 ± 3 °C and 38 ± 7 % R.H. under red lighting.

Results and Conclusion

Three samples Sample1 (*Aloe vera*), Sample2 (silver-nano) & Sample3 (Dual finished) was analyzed and the results were discussed. The anti microbial and odor retention property of dual finished non woven samples is superior to that of single finished non woven samples.

Effect of odor retention and anti microbial efficacy on *Aloe vera* treated samples

The mean ratings for odor intensity for each non woven fabric stored for different time periods were studied and the results are tabulated in Table 2. Differences in these ratings were apparent, most strongly influenced by the concentration of *Aloe vera* from which the non woven sample treated with 100% concentration having the highest rating and sample with 75% concentration, the lowest. The samples treated with 50% *Aloe vera* concentration were rated as low in odor intensity. A high intensity of odor was perceived on 100% *Aloe vera* treated non woven sample, the intensity remaining

high after one week and even after 28 days. 75% *Aloe vera* treated non woven sample was rated low in odor over all time periods. For each time period, the same trend among the nonwoven fabrics was existed. 100% *Aloe vera* treated nonwoven sample was rated more intense than 75% and 50 % treated samples. Some variability in the data was evident, a result of daily fluctuations in bacterial numbers and odor.

Despite this variability, some structural differences were still detected amongst the 100% *Aloe vera* treated nonwoven sample. Therefore, it was the 50% *Aloe vera* treated non woven sample that tends to be less odorous than the 75% and 100% a *Aloe vera* treated non woven samples as shown in Fig1. The anti microbial property of the *Aloe vera* treated samples was also studied as per the standards and it is found to be significantly poor when compared to nano silver treated samples as listed in Table 3. From Table 4, it is evident that there is no significant difference existing between odor intensity and the concentration level of the *Aloe vera* treated samples.

Table 2: *Aloe vera* treatment vs Odor intensity of the samples

Samples	Conc.	Odor intensity
1	50%	14 days
2	75%	21 days
3	100%	28 days

Table 3: Reduction rate of bacterial colonies in *Aloe vera* treated samples

Samples	<i>Staphylococcus aureus</i> (mm)	<i>E. coli</i> (mm)	Overall bacterial reduction (%)
1	5	8	20
2	4	10	50
3	3	12	30

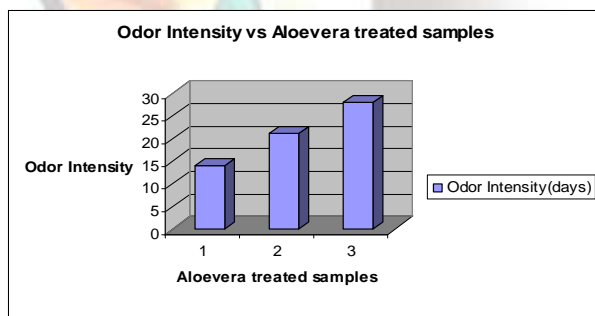


Fig 1: Odour intensity vs *Aloe vera* treated samples

Table 4 Two way ANOVA for aloe vera treated samples

Sources of Variation	Sum of Squares (S S)	Degrees of Freedom (D F)	Mean squares (M S)	Variance "F" ratio
Between odor intensity of the samples	551.11	3	183.7	2.19
Between different treatment methods	667.56	3	222.5	2.15
Residual	755.67	9	83.97	
Total	1974.94	15		

Effect of anti microbial efficacy and odor retention on nano silver treated samples

To evaluate the effect of the different concentrations of silver-nano on antimicrobial activity, the samples are treated with the solution concentration of 3%, 5% & 7% ovm respectively. Because the antibacterial mechanism of silver-nano is the barrier type, the antibacterial activity was measured quantitatively to determine the effectiveness of the treatment in reducing the bacterial colony count of *Staphylococcus aureus* & *E Coli* as listed in Table 5. 7% silver-nano treated sample showed a reduction rate as high as 42mm in number of bacterial colonies of *Staphylococcus aureus* and 51mm in number of bacterial colonies of *E coli*. 5% silver-nano treated sample showed a lower reduction rate as 29mm in number of bacterial colonies of *Staphylococcus aureus* and 38mm in number of bacterial colonies of *E coli*. 3% treated silver-nano sample showed even lower reduction rate as low as 34mm in number of colonies of *Staphylococcus aureus* and 47mm in number of bacterial colonies of *E coli*. 7% dual finish sample show a reduction rate as high as 8mm in number of bacterial colonies of *Staphylococcus aureus* and 10mm in number of bacterial colonies of *E coli*. 5% dual finished sample showed a lower reduction rate as 6mm in number of bacterial colonies of *Staphylococcus aureus* and 12mm in number of bacterial colonies of *E coli*. 3% dual finished sample showed a lower reduction rate as 5mm in number of bacterial colonies of *Staphylococcus aureus* and 16mm in number of bacterial colonies of *E coli*. The odour retention property of the nano silver treated samples was also studied as per the standards and it is found to be significantly poor when compared to *Aloe vera* treated samples as shown in Fig 2. From Table 5, it is

evident that there is no significant difference existing between bacterial reduction colonies and the concentration level of the silver-nano treated samples.

Table 5 Reduction rate of bacterial colonies in silver-nano treated samples

Samples	Zone of inhibition in mm		Overall Bacterial reduction (%)
	<i>Staphylococcus aureus</i>	<i>E.coli</i>	
A	42	51	40
B	29	38	60
C	34	47	50

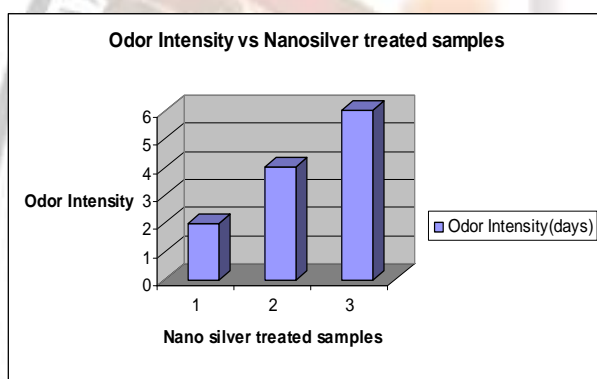


Fig 2 Odour intensity vs Nano silver treated sample

Table 6 Two way ANOVA for silver-nano treated samples

Sources of Variation	Sum of Squares (S S)	Degrees of Freedom (D F)	Mean squares (M S)	Variance "F" ratio
Between Bacterial reduction % of the samples	1838.89	3	612.9	0.23
Between different treatment methods	106.22	3	235.4	0.091
Residual	23079.89	9	2564.4	
Total	25625	15		

Effect of odor retention & anti microbial efficacy on dual treated samples

To impart simultaneous odor absorbency and anti microbial activity we used silver-nano to treat specimens that had been pre treated with *Aloe vera*. To evaluate the effect of different concentrations of the silver-nano solution on the anti microbial activity, we varied the solution concentrations from 3%, 5% & 7% ovm respectively. The reduction rates in the number of bacterial colonies found on dual finished samples at 3% silver-nano concentration & 50% concentration *Aloe vera* were presented in Table 7. Where the dual finished samples treated with 50% *Aloe vera* & 5% silver-nano exhibited good reduction in the number of colonies. For the dual finished non woven there was no significant change in reduction rate after the *Aloe vera* treatment. The reduction rate in number of bacterial colonies found on dual finished samples is very higher at 100% *Aloe vera* and 7% silver-nano concentration. Though the bacterial colonies decreased slightly with increasing silver-nano concentration, the nonwoven pretreated with 100% *Aloe vera* concentration still had higher odor concentration as shown in Fig 3.

Table 7 Reduction rate of bacterial colonies in dual finished sample

Samples	Zone of inhibition in mm		Overall Bacterial reduction (%)
	<i>Staphylococcus aureus</i>	<i>E.coli</i>	
1	8	10	60
2	6	20	75
3	5	16	70

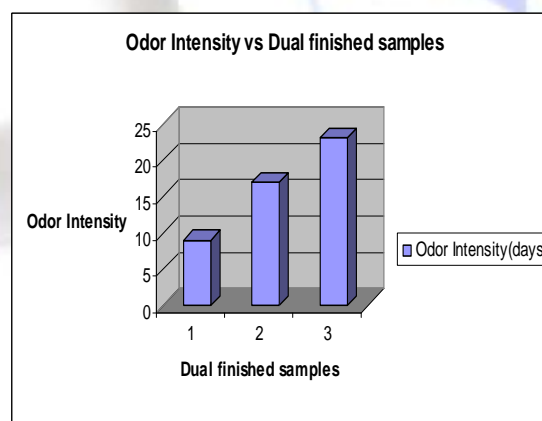


Fig 3 Odour intensity vs Dual finished sample

From the above work, we have concluded that various functional finishes like antimicrobial and odor absorbency can be applied on the insoles to improve its end uses. The project was focused on the development of antimicrobial and odor absorbent nonwoven insole. We have also assessed the antimicrobial and odor absorbent properties of treated samples of varying concentrations. Samples treated with 7% silver-nano showed excellent antimicrobial activity against *Escherichia coli* and *Staphylococcus aureus*. The samples treated with 100% *Aloe vera* showed excellent odor absorbent property. The antimicrobial activity and absorbent property of the dual finished fabrics is superior to that of single finished fabrics.

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