ANTIMICROBIAL AND BLOOD REPELLENT FINISHES FOR COTTON AND NONWOVEN HOSPITAL FABRICS BASED ON SILANE AND FLUOROPOLYMERS

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ABSTRACT

Antibacterial and blood repellent finish has been applied to cotton woven and spun bond nonwoven fabrics used for surgical gowns, bed linens and drapes to reduce the surgical site infections. The silane was applied to the fabric for imparting antimicrobial activity by pad-dry-cure method. The silane treated fabric was then imparted blood repellency through the fluoropolymer (4%, 5% ,6% and 7% owf) using pad-dry-cure method. The cotton nonwoven and spunbond nonwoven fabrics indicate a realistic antibacterial effect.co-application of silane with fluoropolymer on different sample also showed a good antibacterial, blood repellency property.

1. INTRODUCTION

Textile goods are excellent substrate for growing microorganisms. For the last fifty years, the prevention of microbial attack on textile materials has become increasingly important to consumers and textile producers[1].several dangerous, infectious an blood borne bacteria and viruses, such as pseudomonas, caudida, S.aureus and E.coli, are in attendance in hospital locations which are conductive for increase of the micro organisms. The textile materials such as socks and innerwear faced with smell from body perspiration. Currently there is also an interest in protecting health care workers from diseases that might be carried out by patients. Especially for surgical gowns, drapes, masks, sheets, and pillow cases, there is an increasing need to care for medical staff from infection by blood borne pathogens such as HIV and HBV. Gowns should be able to avoid stricke through or wetting out of the fabric, and so surgical gown materials should have not only antimicrobial properties but also blood barrier properties. In addition the textile used in hotels, transportation and biological institution needs antimicrobial textiles[1]. Textile materials with good opposing to antibacterial attack and cross infection by giving antibacterial and blood repellent finish[2]. Textile materials with controlled release properties can release chemicals in a controlled way. Often there is a continuous slow release of the chemicals but the release can also be envisaged upon a stimulus. The controlled release of chemicals can find many applications, not only in the cosmetic area, where several products are already commercially available, but also in medical applications for controlled release of drugs[3]. Nowadays, nonwoven fabrics are the most commonly used textiles for surgical gowns, patient drapes, laboratory coats, coveralls, and other kinds of protective clothing. There is currently a prominent trend toward increasing the level of hygienic necessities for materials used in both households and in different service sectors. The regulars need for protection from possible infection during stays in hotels and hospitals. Textiles materials are carriers of pathogenic microflora, so that having fabric properties that prevent biological media(blood, wound secretions) from adhering to them and suppressing growth of microorganisms is of great attention. The creation of materials with antibacterial and antiadhesive properties for flaxication of bed linens and medical uniforms will reduce the risk work-related diseases in medical personnel and the spread of infections.[6,10, 11].

Nanotechnologies open a new world in the area of textiles, but many aspects remain unclear, with special emphasis on environmental and health and safety aspects. a variety of classes of chemicals have been introduced to pass on water repellency to the fabrics. Out of them fluoro polymers are importantly used as repellent agent in industry as well as by researchers.

Physical chemistry of wetting: When a drop of liquid on a solid surface does not increase, the drop will assume a shape that appears constant and exhibits an angle , called the contact angle. The angle is characteristic of the particular liquid/solid interaction; therefore, the equilibrium contact angle serves as an indication of wettability of the solid by the liquid. As seen in figure 1, the interfacial forces between the liquid and vapour, liquid and solid and solid and vapour all come into play when determining whether a liquid will spread or not on a smooth solid surface. The equilibrium established between these forces determines the contact angle θ.

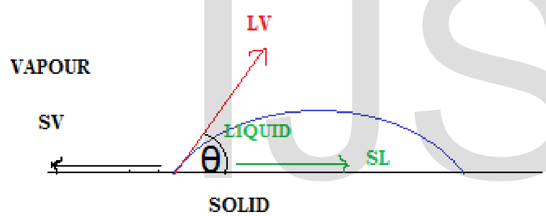

Fig. 1.1. Physical Chemistry Of Wetting Agent

Where θ = the contact angle

γSV = the solid-vapour interfacial free energy

γLV = the liquid-vapour interfacial free energy

(surface tension of the liquid)

γSL = the solid-liquid interfacial free energy

then $\gamma SV = \gamma LV \cos \theta + \gamma SL$

The surface tension of the fabric has to be greatly lesser then that of blood and body fluids whose surface tension ranges between 42 dynes/cm and 60 dynes/cm to produce repellency. The surface tension of fluoropolymer water repellent agent is 10 dynes/cm, which is lower then any other usually used water repellents. now, it is used for imparting the blood repellency to the fabric[4&5].

The antibacterial activity of the customized materials was recognized as a result of microbiological test conducted according to the recommendations in the action was characterized by the growth inhibition zone of microorganisms in agar infected with staphylococcus, aureus (10^4cells/ml) for a sample[6].
Then the drop absorption was used to estimate the water and blood repellency of the fabrics. To do this droplet of water or blood (synthetic blood) from sample of fabric fall down on the fabric outside and the time of droplet fading was recorded.

2. MATERIALS AND METHODS

2.1. Fabric Preparation

100% cotton plain woven fabric, made up of 62s combed yarn with 110 ends/inch and 84 picks/inch, was desized prior to the appliance of the antimicrobial finish and blood repellent finish. And spunbond non woven fabrics made up 32 GSM. The fabrics are purchased from alpha and garuda nonwovens Mumbai the chemicals are purchased from Spiro speciality tirupur.

2.2. Application of Antibacterial Finish onto Fabrics

Silane was coated to the fabric by pad-dry-cure method. The fabric was padded with the take out to attain a wet pick-up of 75%, dried and then cured at 100-120°C for 2 min. In order to fix the active silane substance on the fabric, a post treatment with 10 % citric acid was given, keeping material- to- liquor ratio of 1:20 at 50°C for 5 min. The treated fabric samples were then dried at 80°C and cured at 140° C for 2 min.

2.3Application of Blood Repellent Finish

In this work, dual finishes of antibacterial and blood repellency were imparted to the surgical gown and bed linen fabrics. The antibacterial finished materials were post treated with fluoropolymer independently by the following methods.

2.3.1fluoropolymer treatment

RECIPE:

Fluoropolymer : 40g/L, 50g/L, 60g/L and 70g/L.

Silane (AM 1000) :20 g/L

IPA(isopropyl alcohol):15g/L

PH :5 to6

The fabrics were treated separately with 4%, 5%, 6% and 7% fluoropolymer using the above recipe by pad-dry-cure method to attain a wet pick-up of 75%, dried at 130°C and cured at 150-160°C for 2 min.

2.4. Test Methods for Assessing the Antimicrobial Finish

In this work, the qualitative agar diffusion test and the quantitative bacteria reduction through .AATCC 100-2004 test were used to assess the antimicrobial activity of the fabrics.

The antibacterial effect of the different concentred silane and fluoropolymer treated sample were determined qualitatively by agar diffusion plate test using EN ISO 20645:2004 method against *Staphylococcus aureus* ATCC 6538 and *Escherichia coli* ATCC 10229. When effective antibacterial activity was determined against the used bacterial pathogens, AATCC 100-2004 test method was used to analyse reduction in bacterial counts for quantitative determination.

2.4.1Agar diffusion method (EN ISO 20645)

Qualitative antimicrobial determination by EN ISO 20645:2004 method employs a two layered agar plate. The lower layer has sterile culture medium and the upper layer of agar was inoculated with individual test bacteria ($1X10^8$ cells). Test specimens were imprinted onto the inoculated agar using sterile forceps. Agar plates were incubated for 18-24 h at 37ºC. Assessment of antibacterial activity was determined by the extent of bacterial growth in the contact zone between the agar and the specimen.

2.4.2Antibacterial quantitatively method (AATCC 100-2004)

The antimicrobial activity was quantitatively evaluated using AATCC 100-2004 test method against the standard bacterial strain which gets effectively inhibited by EN ISO 20654:2004 method. The treated samples were inoculated with bacterial inoculums ($1X10^5$ cells/ml). After incubation sterilized distilled water was added for serially dilution. From every dilution 1ml of diluted solution was plated on agar medium and incubated for 24 h at 37 ± 2°C.

2.5. Test Methods for Assessing Blood Repellent Finish

The blood repellency of the sample was assessed using impact penetration and spray test. The synthetic blood was prepared using distilled water, a surfactant (Acrysol G110, Rohm and Hass Co) and red dye (Direct Red 081) according to ASTMF 23.40.01(draft) for testing the resistance of protective clothing material to synthetic blood[2,8,9].

2.5.1. Impact Penetration Test (AATCC 42 -2000)

A volume of water/synthetic blood was allowed to spray against a taut surface of the test specimen backed by a weighed blotter. The blotter was then reweighed to determine water penetration and the specimen is classified accordingly. The specimen 178× 330mm and the blotting paper were conditioned in an atmosphere of 65± 2 % RH and 2 1 °C temperature for at least 4 h before testing. The increase in mass of the blotter in grams was calculated and the average result of the three test specimens was reported.

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ASTM F1670 Significance and Use

This test method is based on Test Method F 903 for measuring resistance of chemical protective clothing materials to penetration by liquids. This test method is normally used to evaluate specimens from individual finished items of protective clothing and individual samples of materials that are candidates for items of protective clothing. Finished items of protective clothing include gloves, arm shields, aprons, gowns, coveralls, hoods, and boots. The phrase "specimens from finished items" encompasses seamed and other discontinuous regions as well as the usual continuous regions of protective clothing items.

Medical protective clothing materials are intended to be a barrier to blood, body fluids, and other potentially infectious materials. Many factors can affect the wetting and penetration characteristics of body fluids, such as surface tension, viscosity, and polarity of the fluid, as well as the structure and relative hydrophobicity or hydrophobicity of the materials. The surface tension range for blood and body fluids (excluding saliva) is approximately 0.042 to 0.060 N/m (1). To help simulate the wetting characteristics of blood and body fluids, the surface tension of the synthetic blood is adjusted to approximate the lower end of this surface tension range. The resulting surface tension of the synthetic blood is approximately 0.042 ± 0.002 N/m. The synthetic blood mixture is prepared with a red dye to aid in visual detection and a thickening agent to simulate the flow characteristics of blood. Part of the protocol in Procedure for exposing the protective clothing material specimens with synthetic blood involves pressurization of the test cell to 13.8 kPa (2 psig). This hydrostatic pressure has been documented to discriminate between protective clothing material performance and correlate with visual penetration results that are obtained with a human factors validation. Some studies, however, suggest that mechanical pressures exceeding 345 kPa (50 psig) can occur during clinical use. Therefore, it is important to understand that this test method does not simulate all the physical stresses and pressures that are exerted on protective clothing garments during actual use. This test method is offered to identify those protective clothing materials that warrant further evaluation with a microbiological challenge.

2.6. Spray Test (AATCC 22 -1996)

Water sprayed against the taut surface of a test specimen under control conditions produces wetted pattern whose size depends on the relative repellency of the fabric. Specimen of 18×18cm size was conditioned at 65± 2 RH and 21° ± 1°C. Evaluation is accomplished by comparing the wetted pattern with the observations as mentioned in the following standard rating
The spray rating is determined by comparing the appearance of the tested specimen with descriptive standards and photographs. The AATCC Spray Test Rating Chart is available for this purpose.

2.6.1. How to Order

1. 901-302 SPRAY RATING TESTER – MODEL 513 ACCESSORIES
2. 510-315 Spare Spray Nozzle
3. 393-253 Spare Specimen Holder
4. 766-456 AATCC Spray Test Rating Chart
5. 201-513 ISO Certificate of Calibration

2.6.2. Standard Observation rating

1. 100 (ISO-5) Sticking or wetting of upper surface
2. 90 (ISO-4) Slight random sticking or wetting of upper surface
3. 80(ISO-3) Wetting of upper surface of spray points
4. 70(ISO-2) Partial wetting of whole of the upper surface
5. 50(ISO-1) Complete wetting of whole of upper surface

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3.0. RESULTS AND DISCUSSION

the cotton woven and spunbond nonwoven fabrics treated with the silane shows very good resistance to both gram positive and gram negative bacteria and durability also good .

3.1. Antibacterial Efficacy of Silane Treated Fluoropolymer Finished Fabrics

The result of agar diffusion test for antimicrobial effectiveness against Staphylococcus aureus and E.coli cultures. Specimen represents Silane treated fluoropolymer finished sample. The antibacterial activity of the silane treated fluoropolymer finished samples at 4 different concentrations of fluoropolymer deposited samples based on agar diffusion and the method is given in It can be inferred that the antimicrobial efficacy reduces apparently with the increase in fluoropolymer concentration. This may be due to the increase in add-on of fluoropolymer; especially the higher concentration makes the fabric surface highly hydrophobic and considerably restricts the release of antimicrobials.

3.1.1. Antibacterial effect of silane and fluoropolymar treated samples

Table 1: EN ISO 20645:2004 Antibacterial Assay qualitative Method

Sample No	Chemicals used	Woven fabrics	Non-woven fabrics
1	Silane	3mm	3mm
2	Silane with fluoropolymer(4%)	6mm	8mm
3	Silane with fluoropolymer(5%)	27mm	25mm
4	Silane with fluoropolymer (6%)	38mm	37mm
5	Silane with fluoropolymer (7%)	45mm	43mm

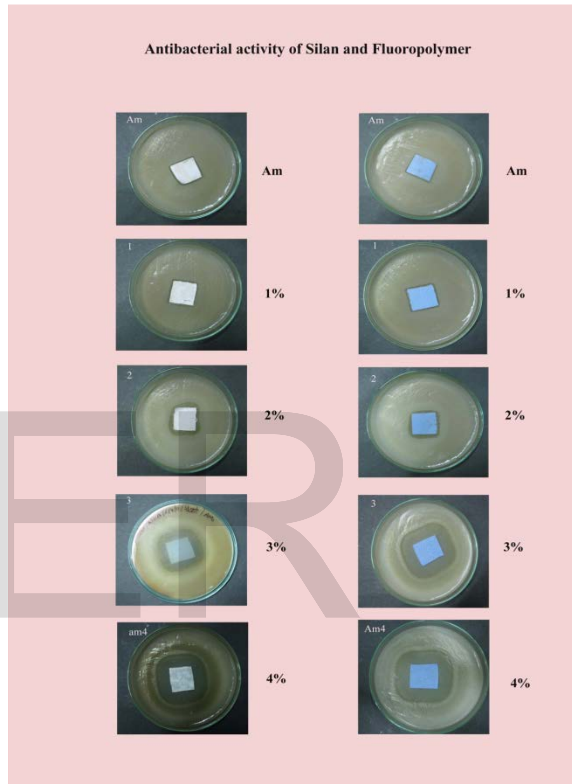

Fig.2.antimicrobial Activity Zone (In mm)

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3.1.2 Quntative antimicrobial analysis

Table. 2. Antimicrobial Test (AATCC Tm 100-2004)

Sample no	Sample no	Bacterial reduction (in %)		
		Staphylococcus aureus,(ATCC6538)	Klebsiella pneumonia (ATCC4352)	Remarks
CC711	Non- woven with SILANE Treated	100	100	Excellent
CC712	Non-woven with silane and fluoropolymer treated	100	100	Excellent
CC713	Woven with SILANE Treated	100	100	Excellent
CC714	woven with silane fluoropolymer treated	100	100	Excellent

In antimicrobial test the result shows that the woven and non-woven fabrics treated with silane and fluoropolymers has an excellent activity and at the same time the blood repellency effect has an excellent .If the concentration increases the antimicrobial activity increases. These results are achieved. The result showed in table 1 and 2 both qualitative and quantitative methods .

3.3. Effect of Fluoropolymer Treatment on Blood Repellency

It is observed that the amount of synthetic blood penetrating the sample is reduced with the increase in fluoropolymer concentration (Table 3). The spraying rate also improves with the increase in fluorocarbon concentration. It may be concluded that the result concentration of fluoropolymer is increased then the blood repellency also increased..

3.3.1. Spray Test:

Table 3. Spray Test

TEST PARAMETER	cc7311	cc7312	cc7313	cc7314	cc7315
	Un Treated Woven	Fluoropolymer treated			
		40 gpl	50 gpl	60 gpl	70 gpl
Blood repellency	0	90	90	Above 90	Above 90
TEST PARAMETER	cc7317	cc7318	cc7319	cc7320	cc7321
	Un Treated non-Woven	Fluoropolymer treated			
		40 gpl	50 gpl	60 gpl	70 gpl
Blood repellency	0	90	90	Above 90	Above 90

Standard Observation rating

I. 100 (ISO-5) Sticking or wetting of upper surface
II. 90 (ISO-4) Slight random sticking or wetting of upper surface
III. 80(ISO-3) Wetting of upper surface of spray points
IV. 70(ISO-2) Partial wetting of whole of the upper surface
V. 50(ISO-1) Complete wetting of whole of upper surface

In the spray test woven and non woven fabrics has been taken these fabrics are treated with fluoroploymers under four concentration of 4%,5%,6% &7% In that the blood repellency effect is 90 in (4% &5%) and above 90 in (6% &7%).The observation of 90 is slight random sticking (or) wetting of upper surface. Above 90 is sticking or wetting in upper surface.

3.3.2. Penetration Test:

In the penetration test the untreated woven and non-woven fabrics has been taken in that blood penetration takes place so its fail. The woven and non-woven fabrics treated with fluoropolymers under four concentration of (4%,5%,6% &7%).The result is pass in both the fabrics if the concentration increases the blood repellency effect is also increases. The result pass showed in table 4

Table 4. Penetration Test

samples	Materials (Treated with fluoropolymer)	Result
CC7311	Untreated woven	Fail
CC7312	40gpl	Pass
CC7313	50gpl	Pass
CC7314	60gpl	Pass
CC7315	70gpl	Pass
CC7316	Untreated non-woven	Fail
CC7317	40gpl	Pass
CC7318	50gpl	Pass
CC7319	60gpl	Pass
CC7320	70gpl	Pass

3.3.3 Drop Test

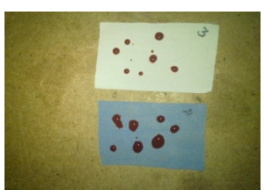

Fig. 2. Untreated Sample, Fig. 3. Treated Sample

In the drop test the untreated woven and non woven has the spreading effect of drops of blood that shows in fig(3.2).In the figure(3.3)shows the treated woven and non-woven fabrics with fluoropolymer the drops of blood does not spreads on the fabrics.

4. CONCLUSION

When fluoropolymer concentration increases the blood repellence increases and same time antimicrobial activity will be increased. Antibacterial and blood repellent cotton woven and spunbond nonwoven fabric were prepared by directly incorporating of silane and fluoropolymer on the fabrics. An interesting observation is the clear zone of inhibition and excellent bacteria growth. 2% of silane is enough for producing an excellent protective both woven and nonwoven fabrics. Then the 4% of fluoropolymer give optimum result when increases the concentration of fluoropolymer and it is give excellent blood repellency.

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BIOGRAPHIES

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