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Application of Eco-friendly Antimicrobial Finish *Butea monosperma* Leaves on Fabric Properties of Polyester and Cotton/Polyester

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Abstract. The study was aimed to check the effect of eco-friendly antimicrobial finish on 100% polyester and 50/50 cotton/polyester woven fabrics. The leaves' extract of *Butea monosperma* was used as an eco-friendly antimicrobial finish. The fabric was first desized, scoured, bleached and washed then antimicrobial finish was applied by using pad dry cure method. The aesthetic, comfort and mechanical fabrics properties were checked before and after applying antimicrobial finish. Under aesthetic property stiffness and smoothness appearance was checked, under comfort related property absorbency and air permeability was checked and under mechanical property tear and tensile strength was checked. The antimicrobial finish was checked by using ASTEM E2149 Shake Flask method. The AATCC and ISO standard testing methods were used for checking fabric properties. One way ANOVA statistical test was applied for analysis of results. Antimicrobial finish has increased aesthetic (stiffness, smoothness appearance), comfort (absorbency, air permeability) and mechanical (tensile and tear strengths) properties of polyester and cotton/polyester fabrics. The antimicrobial finish was effective on both 100% polyester and 50/50 cotton/polyester fabrics up to 25 washes. This study is beneficial to medical industry, paramedical staff, sports wears, home furnishing as well as common people.

Keywords: antimicrobial finish, *Butea monosperma*, polyester, cotton, polyester

Introduction

For long period of time it has been known that fabrics provide perfect environment for microorganisms development and reproduction. Microorganisms development on fabric is seen during use as well as during storage, so this growth causes health issues to consumers (Sathianarayanan *et al*., 2010), as well as damage to the physical and mechanical performance of the fabrics. The adverse changes include discoloration, bad odour, mould formation, allergies, detrimental infection, fabric degradation and other related problems (Simonic and Tomsic, 2010).

Therefore, it is very essential to finish all apparels by antimicrobial action to check the bacterial development on fabrics without abolishing desirable features of fabrics. These antimicrobial treated fabrics are used in medicinal garments, carpets, napkins, sanitary, socks and disposable wipers etc. A variety of synthetic anti-bacterial agents have been used on fabric such as phenols, organo silicones, organometallics and quaternary ammonium salts. These are more intricate and producing ecological contamination (Joshi *et al*., 2009). There is need of this type of fabrics in defensive clothes used in hospitals, schools, nursing homes, guesthouses and jam-packed public areas. There is a vital market requirement to apply antimicrobial finish to avoid bad smell in intimate apparel, underclothing, socks and sporty wear (Periolatto *et al*., 2012).

Natural and synthetic fabrics differ significantly in reactions to bacterial development. They equally perform as ready substrates; however, the appliance in the two circumstances is diverse. Fibres which are obtained from natural sources are responsible for bacterial attack for the reason that they absorb water molecules eagerly, and bacterial enzymes can eagerly breakdown their polymer bonds. In natural fibre category cotton, wool and jute are described to be greatest subject to micro-organism attack as well as silk and flax. If on 0.5 g cotton 105 colonies (in 1 mL water) are pragmatic then logarithmic progression is detected after a few hours. The inhabitants rise from 105 to 109 clusters (Hong *et al*., 2012). The development of microorganisms is sluggish on synthetic fabrics in contrast to natural

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fabrics. The reason is that on synthetic fabrics microorganisms does not hold much water in their polymer backbone. Though, these fabrics support the holding of moisture in spaces, where these microorganisms reproduce quickly. For instance, foot infection is more noticeable in synthetic fabric socks as compared to socks made from natural fabrics. Hence, for comparison and to gain a good knowledge about microorganism presence on different fabrics, natural, synthetic and blend fabrics was used in current study (Olderman, 1997; Payne and Kudner, 1996).

Due to superior life and health point of view the antimicrobial finished has received tremendous importance in industry as well as in education research. Microbes that are present on fabric are responsible for damaging colour, causing bad odor, illness as well as destruction of fabric. Antimicrobial finish can be applied on sports clothing, towels, undergarments, medical clothing, shoes and upholstery etc. (Varesano *et al*., 2011). Currently, due to growing awareness of eco-friendly issues and also contamination formed by the use of synthetic dyes, there is increasing interest in dyeing of fabrics using natural dyes. Due to the reason of its improved biodegradability and greater compatibility with the atmosphere, eco-friendly antimicrobial finish lead to relatively little poisonous and allergic responses. From ancient time the remedial power of specific plant resources have been used successfully. According to one estimation there are about 250,000-500,000 kinds of such plants in the world. There are also plants which have antimicrobial property (Ali and El-Mohamedy, 2011).

The new procedure were used such as chitosan action (Dev *et al*., 2009), plasma action (Ghoranneviss *et al*., 2011; Chena and Chang, 2007), cationization (Hong *et al*., 2012), enzymatic action (Raja, 2011), microencapsulation and cross-linking (Sathianarayanan *et al*., 2010) procedures for improvement in antibacterial action by dying fabric with herbal agents. These advanced procedures proved of vast help in enhancement of bioactive properties of final goods. Mahesh *et al*. (2011) applied pomegranate, neem and turmeric on fabric which resulted in 42%, 38% and 29% resistance against *E. coli* and *B. cereus*. In another study, chitosan and chitosan/PEG were applied on fabrics that showed resistance to *S. aureus*. The effect of the finish lasted up to 5 washes (Bonin, 2008).

In traditional drugs, there are several herbal medicines that have the ability to treat several illness and sicknesses, one of them is *Butea monosperma*, generally known as 'dhak' or 'palas', ‘Flame of forest’. It has several medicinal characteristics and in certain communities gum of *B. monosperma* is used to treat bacteriological and fungal contaminations.

In order to develop a better understanding of the phenomenon, the current study was conducted to assess the antimicrobial properties of leaves of *B. monosperma* by agar diffusion method and fabric properties were checked before and after applying antimicrobial finish (Malpani *et al*., 2012).

Materials and Methods

In this study eco-friendly antimicrobial finish was extracted from leaves of *Butea monosperma* and applied on 100% polyester and 50/50 cotton/polyester blend. Microorganism’s presence was studied on fabrics before and after applying antimicrobial finish. To study the effect of finish on fabrics comfort, mechanical and aesthetic properties were checked. The polyurethane binder was used to improve durability in home laundry. This binder was taken from CHT. The microorganism’s presences was checked up to 25 washes in comparisons of control group.

The fabrics samples were cut then treated with antimicrobial finish and tested to govern their effectiveness as antimicrobial fabrics. Extractions of antimicrobial agents from plant were carried out in laboratory of Botany Department of Government College University, Lahore, Pakistan. Antimicrobial finish was applied in National Textile University Faisalabad (NTU). Antimicrobial testing was carried out in Centre of Excellence in Microbiology (CEMB). The fabrics properties were checked in NTU. To check the effect of the antimicrobial finish of 100% polyester and 50/50 cotton/polyester, first fabrics properties of untreated samples were tested then antimicrobial finish was applied. Again same fabric properties were checked to see whether the properties after applying finish remain same, increase or deteriorate.

Fabric sample. Samples of fabrics 100% polyester and 50/50 cotton/polyester were purchased from fabric trader of Faisalabad. After purchasing the fabric it was approved by Dean of Faculty of Textiles Engineering & Technology of Faisalabad. Sample size was 5 yards depending upon, checking fabric properties and tests. The specification of fabrics is given in Table 1.

Table 1. Fabric specification

Name			Properties			
	Supplier	Fibre content	Fabric construction	Weight	Warp	Weft
100% polyester	Faisalabad	100% polyester	Twill weave	0.82 g 82 Gsm	58	58
50/50 cotton/polyester	Faisalabad	50/50 cotton/polyester	Plain weave	2.17 g 217 Gsm	70	55

Unfinished fabric was taken and after purchasing it was processed in NTU. The cotton/polyester 50/50 fabric was desized by using enzyme Bactasal HTN was used in ratio of 1g/L. pH was 5-6 and temperature was 60-70 °C, fabric was dipped for 45 min in this solution. After desizing the fabric scouring was done by using NaOH 4 g/L and wetting agent 2 g/L, detergent was used in the ratio of 1 g/L, 90 °C temperature was maintained during the process. The cotton/polyester fabric was dipped for 1 h in bleaching agents which consisted H_2O_2 5 g/L, NaOH (pH 10-10.5) 2 g/L, stabilizer 2 g/L and sequesting agent 2 g/L. The temperature of the process was 90 °C. The fabric was dipped in this solution for one hour. In washing of polyester fabric 4 g/L detergent was used. The temperature of bleaching process was 90 °C. The polyester fabric was dipped in washing solution for one hour.

Plants leaves extraction. The leaves of *B. monosperma* were collected in March 2014 from botanical garden of Government College University, Lahore, Pakistan. It was identified and authenticated by Botany Department of Government College University, Lahore. The leaves were washed and shadow dried for two months. After that it was grinded by using a stainless-steel grinder into very fine powder. In Laminar Air Flow Hood poured leaves powder and distilled water (autoclave at 110 degree) in ratio of 100 g grinded leaves powder and 250 mL distilled water. This soaked material was left for 7 days and stirred it twice a day. After that it was filtered by use of muslin cloth then filtered again by using Whatman filter paper. The filtered extract of *B. monosperma* was concentrated by using rotary film evaporator.

Development and application of antimicrobial finish. The antimicrobial finish of *B. monosperma* was prepared in ratio of 200 mL leaves extract, 50 mL poly urethane binder and 150 mL distilled water. The fabric sample was cut which consisted on three meter in length and one foot width from both fabrics, respectively. Labelled it as "un" for untreated and "B" for treated *B. monosperma*. On untreated polyester and cotton/polyester samples no finish was applied while on treated samples *B. monosperma* finish was applied. The untreated sample was the control group and the samples treated with *B. monosperma* leaves extract antimicrobial finish were experimental group. The antimicrobial finish was applied by using the pad dry machine, drying was done at 120 °C for 2 min and curing was done 150 °C for 3 min.

After applying antimicrobial finish, microorganisms presence was checked in CEMB by using ASTEM E2 149 shake flask method. The fabric properties i.e., comfort related (absorbency, air permeability), mechanical (tensile strength, tear strength) and aesthetic (stiffness, smooth appearance) properties were checked on all treated and untreated fabrics and sustainability of antimicrobial finish to home laundry was checked by five washes interval.

In aesthetic property for stiffness test, Shirley stiffness tester was used. The surface appearance was checked by using AATCC Technical Manual 2004 TM 124-2001 203 test method. In comfort related properties absorbency was measured by using AATCC test method 79-2000. The absorbency was measured in seconds. The air permeability as comfort related property was measured by using D737-04 standard test methods. The tear strength was measured by using D1424-07 standard test methods. The tensile strength was measured by using the European Standard EN ISO 13934-1:1999 has the status of a British Standard ICS 59.080.30. Tests on all samples were carried out in a standard atmosphere having a relative humidity of 65 ± 2% at 21 ± 1 °C (70 ± 2 °F). There should be no oil, water and grease on the samples when experiment was conducted.

Results and Discussion

The antimicrobial finish was studied in comparison on control group (untreated fabric) and experimental group (treated fabric). The SEM test was also performed to check the presence of antimicrobial finish on fabrics.

The figure showed the SEM micrographs of untreated and treated polyester fabric with eco-friendly antimicrobial finish of leaves of *B. monosperma*. The application of *B. monosperma* antimicrobial finish is observed clearly on polyester and cotton/polyester fabric.

Effect of antimicrobial finish on aesthetic property of polyester and cotton/polyester fabric. The aesthetic property of polyester and cotton/polyester was checked before and after applying antimicrobial finish. Under aesthetic property stiffness and smoothness appearance was checked, results are given in Table 2.

Table 2 shows that *B. monosperma* plant leaves extracts antimicrobial finish have significant effect (p=0.000) on stiffness (warp and weft) of polyester fabric as compared to control group. A one way ANOVA showed that (p=0.016) of smoothness appearance is statistically significant because it is below then 0.05.

In case of cotton/polyester fabric it shows that *B. monosperma* plant leaves extracts antimicrobial finish have significant effect (p=0.000) on stiffness (warp and weft) of polyester fabric as compared to control group. A one way ANOVA showed that (p=0.016) of smoothness appearance is statistically significant because it is below than 0.05. The stiffness and surface appearance of polyester and cotton/polyester fabrics have increased.

Effect of antimicrobial finish on comfort property of polyester fabric. The comfort related property of polyester and cotton/polyester was checked before and after applying antimicrobial finish. Under comfort related property absorbency and air permeability was checked, results are given in Table 3.

Table 2. Effect of antimicrobial finish on properties of polyester and cotton/polyester fabric

Properties	Samples	Mean difference (I-J)	Standard error	Sig.[b]
Polyester fabric				
Stiffness warp	Control vs *B. monosperma*	-1.467*	0.269	0.001
Stiffness weft	Control vs *B. monosperma*	-0.200*	0.062	0.012
Stiffness (warp+weft)	Control vs *B. monosperma*	-0.900*	0.140	0.000
Smoothness appearance	Control vs *B. monosperma*	-0.230*	0.068	0.016
Cotton/polyester fabric				
Stiffness warp	Control vs *B. monosperma*	0-.633*	0.113	0.001
Stiffness weft	Control vs *B. monosperma*	-0.200*	0.062	0.012
Stiffness (warp+weft)	Control vs *B. monosperma*	-0.480*	0.092	0.000
Smoothness appearance	Control vs *B. monosperma*	-0.230*	0.068	0.016

Table 3. Effect of antimicrobial finish on comfort related property of polyester and cotton/polyester fabric

Properties	Samples	Mean difference (I-J)	Standard error	Sig.[b]
Polyester fabric				
Absorbency	Control vs *B. monosperma*	1.333*	0.471	0.022
Air permeability face	Control vs *B. monosperma*	-43.333*	3.951	0.000
Air permeability back	Control vs *B. monosperma*	-38.000*	5.196	0.000
Air permeability (face & back)	Control vs *B. monosperma*	-45.300*	5.178	0.000
Cotton/polyester fabrics				
Absorbency	Control vs *B. monosperma*	21.000*	5.802	0.007
Air permeability face	Control vs *B. monosperma*	-8.367*	1.904	0.002
Air permeability back	Control vs *B. monosperma*	-4.100	1.782	0.050
Air permeability (face & back)	Control vs *B. monosperma*	-7.460*	3.152	0.031

Table 3 shows that *B. monosperma* plant leaves extracts antimicrobial finish have significant effect (p=0.022) on absorbency of polyester fabric as compared to control group. A one way ANOVA showed that (p=0.000) of air permeability (face and back) is statistically significant because it is below than 0.05.

In case of cotton/polyester fabric result shows that *B. monosperma* plant leaves extracts antimicrobial finish have significant effect (p=0.007) on absorbency of cotton/polyester fabric as compared to control group. A one way ANOVA showed that (p=0.031) of air permeability (face and back) is statistically significant because it is below than 0.05. The absorbency and air permeability have increased of both fabrics.

Effect of antimicrobial finish on mechanical property of polyester fabric. The mechanical property of polyester and cotton/polyester was checked before and after applying antimicrobial finish. Under mechanical property tear and tensile strength was checked and the results are given in Table 4.

Table 4 shows that *B. monosperma* plant leaves extracts antimicrobial finish have significant effect (p=0.042) on tensile strength (warp + weft) of polyester fabric as compared to control group. A one way ANOVA showed that (p=0.000) of tear strength (warp+weft) is statistically significant because it is below than 0.05.

In case of cotton/polyester fabric result shows that *B. monosperma* plant leaves extracts antimicrobial finish have significant effect (p=0.034) on tensile strength (warp+weft) of cotton/polyester fabric as compared to control group. A one way ANOVA showed that (p=0.000) of tear strength (warp+weft) is statistically significant because it is below then 0.05. The tear and tensile strength of both fabrics have increased. In one study the antimicrobial finish was applied by use of chitosan and chitosan PEG on cotton fabric and result revealed that it increased the tensile strength. This study support the present study (Bonin, 2008). In another study Sericin was applied on cotton fabric by pad dry cure method. The tensile strength is increased by this treatment. This study support the current study (Doakhan *et al*., 2013).

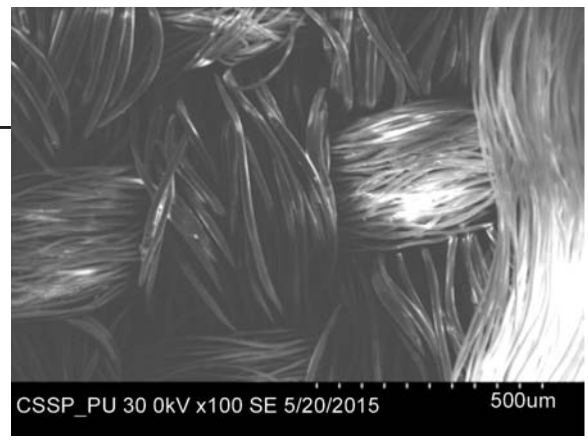

Fig. 1. SEM micrograph of untreated polyester fabric.

Table 4. Effect of antimicrobial finish on mechanical property of polyester and cotton/polyester fabrics

Properties	Samples	Mean difference (I-J)	Std. error	Sig.[b]
Polyester fabric				
Tensile strength warp	Control vs *B. monosperma*	-139.034*	42.146	0.011
Tensile strength weft	Control vs *B. monosperma*	-32.877	27.482	0.266
Tensile strength (warp + weft)	Control vs *B. monosperma*	-68.191	35.331	0.042
Tear strength warp	Control vs *B. monosperma*	-1646.667*	163.095	0.000
Tear strength weft	Control vs *B. monosperma*	-1654.617	160.213	0.000
Tear strength (warp + weft)	Control vs *B. monosperma*	-1558.000*	126.720	0.000
Cotton/polyester fabric				
Tensile strength warp	Control vs *B. monosperma*	130.106	58.482	0.042
Tensile strength weft	Control vs *B. monosperma*	125.206	55.518	0.054
Tensile strength (warp + weft)	Control vs *B. monosperma*	13.681	92.422	0.034
Tear strength warp	Control vs *B. monosperma*	413.333*	131.656	0.014
Tear strength weft	Control vs *B. monosperma*	1020.000*	154.704	0.000
Tear strength (warp + weft)	Control vs *B. monosperma*	766.000*	125.618	0.000

Microorganisms testing after fabric washes. A summary of microorganisms testing after five washes interval is given in Table 5.

Table 5. Quantitative analysis test results of treated and untreated polyester sample

	Polyester		Cotton/Polyester 50/50	
Washes	Untreated	*B. monosperma*	Untreated	*B. monosperma*
0	1	0	1	0
5	0	0	0	0
10	0	0	1	0
15	0	0	0	0
20	1	0	0	0
25	1	0	0	0

On untreated and treated fabrics only those microorganisms were studied which were detected during the experiment. On 100% polyester, were gram –ve short thin rods, coccus, coccus bacilli and gram +ve cocci cluster were observed. On untreated cotton/polyester fabric gram –ve coccus and fungus were observed. The reason was that antimicrobial finish was effective against microorganisms. Crosstab statistical technique was used. The polyester and cotton/polyester fabric treated with *B. monosperma* showed 100% reduction against after 25 successive washes, while on untreated fabrics microorganisms presences was observed. In another study chitosan and chitosan/PEG antimicrobial finish was applied on cotton fabric. The AATCC standard test method was used for antibacterial testing against *Staph. aureus*. Results showed that antibacterial samples showed bacterial resistance up to 25 washes, while the samples laundered 50 time revealed no resistance against *Staph. aureus*. This study support the present study that antimicrobial finish was effective up to 25 washes (Bonin, 2008). The antimicrobial finish was extracted from *Aloe vera* plant and applies on 100% cotton fabric by pad dry method. The AATCC agar diffusion method was used to check antimicrobial testing against *S. aureus*. The treated sample exhibited 98% reduction against *Staph. aureus* after 50 laundries. This study also support the present study that antimicrobial finish can be affective up to 25 washes as it is effective up to 50 washes. This study reduces 98% reduction of microbes while present study reduces 89% reduction in microorganisms (Jothi, 2009). The antimicrobial finish of neem, turmeric and

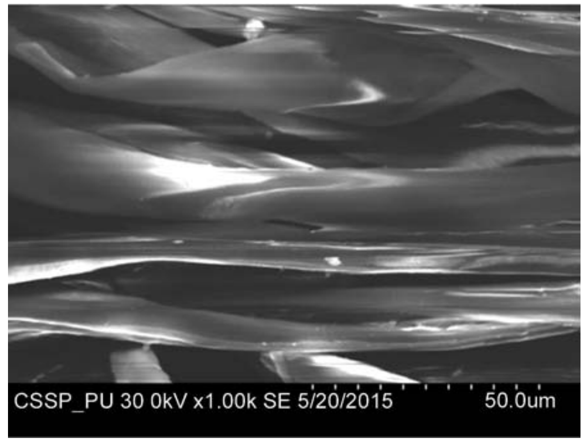

Fig. 2. SEM micrograph of treated polyester fabric.

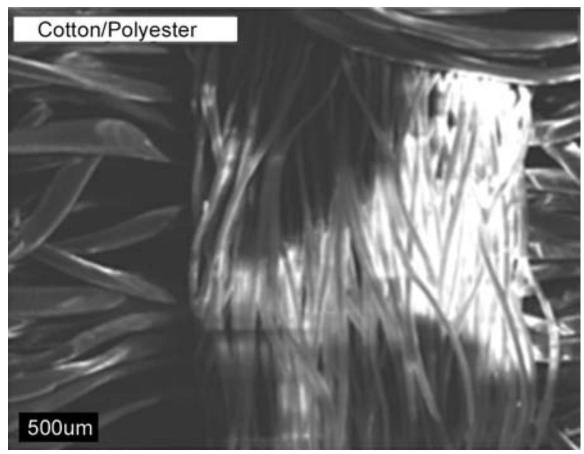

Fig. 3. SEM micrographs of treated cotton-polyester fabric.

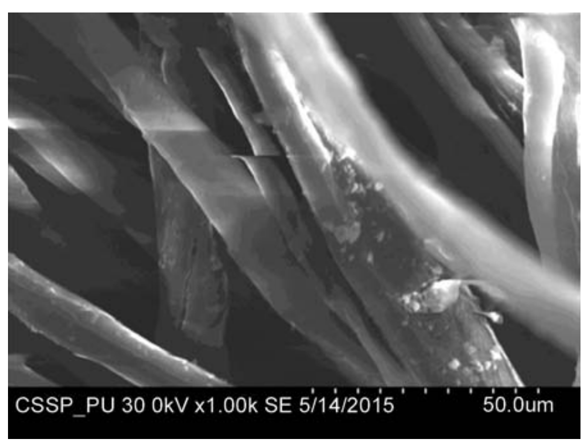

Fig. 4. SEM micrographs of untreated cotton-polyester fabric.

pomegranat was applied against *E. coli* and *B.cereus*. This finish lasts only up to 5 washes. This study somehow also support the present study as it lasts up to 5 washes (Mahesh *et al*., 2011).

Conclusion

The *Butea monosperma* antimicrobial finish was applied on 100% polyester and 50/50 cotton/polyester fabrics. The SEM results showed the presences of finish on fabrics. Fabrics properties were checked before and after applying antimicrobial finish. In aesthetic property, stiffness was increased and smooth appearances remain same. In comfort related property, absorbency and air permeability was increased. As antimicrobial finish was applied, it pushed apart the molecules of fabric and make it space by forming bond with fabric OH group. As finish applied in solution form due to which absorbency increased as well as air permeability was also increased. As spaces present for water (absorbency) so these spaces also caused increased absorbency. In mechanical property tear and tensile strength was increased. The presences of microorganisms was checked before and after applying antimicrobial finish up to 25 washes by five washes interval. The ASTM shake flask method was used to check antimicrobial finish. The results showed that *B. monosperma* showed 100% reduction against microorganism up to 25 washes.

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