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## Effect of Plant based Antimicrobial finishes on Polyester fabric

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**ABSTRACT:** *Microorganisms are present everywhere in the environment and can be helpful for mankind in number of ways. Their harmful effects on cloths can be prevented by using a simple antimicrobial finish in fabrics. In this cross-sectional study, an eco-friendly antimicrobial finisher were extracted from leaves of Azadirachata indica, Butea monosperma and Litchi chinensis plants and applied on 100% polyester. The plant leaves were extracted, grinded, soaked and filtered by Whatman filter paper. It was concentrated by rotatory evaporator. The antimicrobial finish was applied on polyester fabric by the pad dry cure method and fixed by using polyurethane binder. The presence of antimicrobial finish on fabric was checked by ASTEM E2149 shake flask method. There was no microbial growth, even after 22 hours or after 6 days interval in experimental group. The eco-friendly antimicrobial finishes made 89% reduction in microbial growth. All three experimental group do not allow any microbial colony to grow while eight colonies were observed in control group. Extract obtained from L chinensis may cause little damage in surface of fabric. So, it was concluded Antimicrobial finishes are suitable to provide protection against microorganisms and can be used for the medical industry, paramedical staff, sportswear, home furnishing as well as for use of common people.*

**Keyword:** Antimicrobial finish, Polyester, Azadirachata Indica, Butea Monosperma, Litchi Chinensis

## INTRODUCTION

Microorganisms are present everywhere in surroundings such as in homes and hospitals, so human beings are

frequently exposed to them. Textiles provide enormous surface zone and moisture for bacterial development (Sauperl, 2016). Polyester fibers that

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obtained from natural sources such as cotton and silk provide dampness, oxygen, nutrients and temperature for bacteria development and duplication. It causes bad smell, skin infection, colour deterioration, product deterioration, allergy and other allied sicknesses (Maghsoudi et al., 2021).

The new focus in textile is search for antimicrobial treated fabric in order to guard the wearer from germs as well as to guard the fabric from fibre deterioration. Now-a-days, antimicrobial finishes have gained great importance not only in textile industry but also in educational researches due to its importance in giving good quality life and protection benefits to human beings (Zanoaga and Tanasa, 2014). Antimicrobial finishes prevent infestation and cross infections. Now a day, customers are demanding commonly functional treatment and antibacterial treatment to guard them from bacteria (Shibly et al., 2021).

There is a wide range of materials on which antimicrobial finish can be applied such as apparel for doctors, nurses, patient, premature babies, sportswear, socks, babies, older people, soldiers, miners and in home furnishing; it can also be applied for bed sheets, curtains, carpets as well as for use of common people (Rajput et al, 2017). Antimicrobial fabrics should be used for patients, premature children who have low immune system, doctors, nurses and parents of pre mature children. It is

applied on undergarments of both of grown up and kids. These fabrics are also applicable to the sportswear and footwear businesses (Gressier et al., 2019). With advancement in technology, the need of remain hygienic has also increased. The use of antimicrobial finishes in textile industry is no longer a choice but also a need of time (Raja and Thilagavathi, 2011).

Resins, oils and finishes obtained from natural sources like plants have a great antimalarial, antifungal and antibacterial properties (Alihosseini, 2016). Plant based antimicrobial finishes have multifunctional importance. They are not only antibacterial in nature but also give fragrance to fabric (Behary et al., 2020). Knowing the worth of herbal material as antimicrobial agent, there is a need of rigorous research in natural plant material for creating bioactive eco-friendly material in providing protection to wearer from widespread microorganisms that may cause infection. Natural antibacterial agents are recognized non-hazardous and non-allergic (Ahmed et al., 2015). Naturally occurring polyphenolic compounds such as tannin in bark, food and food pods also play important role in dyeing, preservation of leather and as a mordant (Prabhu and Teli, 2011). It is imperative to study extensively natural plants as antimicrobial agents (Morais et al., 2016).

Present research conducted to investigate the antimicrobial properties

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of *A. indica*, *B. monosperma*, and *L. chinensis*. The use of these plants was shown cost effective as compared to metallic (silver) and synthetic chemicals (such as triclosan). The study was carried out in the field of textile by use of eco-friendly (natural) product to make it worthwhile alternative to synthetic product based antimicrobial textiles. Natural plant (*A. indica*, *B. monosperma*, and *L. chinensis*) recognized as antimicrobial agents definitely might lead to develop protective clothing for peoples.

### **MATERIAL AND METHODS**

In the study, antimicrobial finishes was prepared by using three plant leaves i.e. *A. indica*, *B. monosperma*, and *L. Chinensis*. These plants were grown in botany department in Government College University, Lahore Pakistan.

#### **Preparation of Antimicrobial Finishes**

Three autoclaved air tight containers were taken and labelled. Added 100g of dried powder of each plant in 250 ml distilled water and 50 ml binder. The soaked material was kept for seven days and stirred twice a day. Then each prepared material was filtered by using muslin cloth followed by Whatman filter paper and later concentrated by a rotary evaporator. Antimicrobial finish

was prepared and applied in National Textile University (NTU) Faisalabad.

#### **Preparation of fabric sample for testing**

The fabric samples were cut, treated with antimicrobial finish and then tested to govern their effectiveness as antimicrobial fabrics. Binder was obtained from Chemische Fabrik Tübingen (CHT) Pakistan. Polyurethane binder was used as polymeric finishing agent, having slightly yellow colour. Half kg of poly urethane binder was taken from Chemische Fabrik Tübingen (CHT) Pakistan.

#### **Antimicrobial Testing**

Antimicrobial testing was carried out in Centre of Excellence in Molecular Biology (CEMB), Punjab, Pakistan. To check the presence of antimicrobial finish on fabrics pre-test, post-test was conducted. FTIR test was conducted at the Institute of Chemistry, University of the Punjab, SEM test was conducted in The Centre for Solid State Physics, University of the Punjab, Lahore. The control variables (control group) of the study were the untreated fabrics on which antimicrobial finish was not

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applied. In order to minimize the effect of extraneous variables (temperature and humidity), the study was conducted in testing laboratories which have standard testing atmosphere.

### **Application of Concentrated Antimicrobial Finish**

200 ml leaves extract of *A. Indica* was taken from rotary film evaporator in a beaker. Cut one foot width and three feet length fabric sample randomly from 100% polyester fabric. Four more samples of same measurements were taken, one for untreated control group and three were for experimental group.

The dilute concentration of finish was prepared in ratio of 200 ml leaves extract of plant *A. indica* (Neem), 50 ml poly urethane binder and 150 ml distilled water. Same ratio was used for *B. monosperma* and *L. chinensis*. The three meter fabric sample was taken as length and twelve inch as width from cotton fabric; label untreated (un), *A. Indica* (A), *B. monosperma* (B) and *L. chinensis* (L). On untreated cotton samples no finish was applied. On experimental sample A, *A. indica* antimicrobial finish was applied, on

sample B, *B. monosperma* leaves extracted antimicrobial finish was applied and on sample L *L. chinensis* leaves extracted antimicrobial finish was applied respectively.

On pad dry cure machine (process) drying was done at 120°C temperatures for 2 minutes and curing was done 150°C temperatures for 3 minutes. Sustainability of antimicrobial finishes to home laundry were checked by five washes interval up to 25 washes and samples were cut according to each test requirement. The ASTM E2149 Shake Flask Method was used. Each sample was dipped in both concentrated and dilute solution of 100% *A. indica*, *B. monosperma* and *L. chinensis* for two hours. These samples were kept in room temperature to dry. In sterilized petri dishes took 50 ml PBS (phosphate buffer solution) in which fabric samples was soaked individually for one hour with continuous shaking. Label all petri dishes. In laminar air flow hood, prepared agar plates by adjusting pipette man at 50 microliters.

One Way ANOVA tells the statistical difference in application of

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antimicrobial finishes between control group and the experimental group.

fabrics with *A. indica*, *B. monosperma* and *L. chinensis* are shown that it is highly applicable in textile industry as shown in Table 1.

### RESULTS

The result of microorganism's reduction on treated and untreated polyester

**Table 1: Comparison of Microorganisms Colony on Polyester Fabric**

Untreated		<i>A. indica</i>	<i>B. monosperma</i>	<i>L. chinensis</i>	Reduction %
Reading after 22 hours					
1st reading	0	0	0	0	100%
2nd reading	0	0	0	0	100%
3rd reading	0	0	0	0	100%
Reading after 6 days					
1st reading	4	0	0	0	100%
2nd reading	5	0	0	0	100%
3rd reading	3	0	0	0	100%

There was no microbial growth found after 22 hours and even after 6 day interval. Result revealed that polyester fabric showed 89% reduction by the use of *A. indica*, *B. monosperma* and *L. chinensis* leaves extract antimicrobial

finishes as compare to control group. Significant difference (.013) between plant extract and microorganisms' presence on polyester fabric and the effect size was large ( $\eta^2=.409$ ) as shown in Table 2.

**Table 2: Effect of Antimicrobial Finish on Microorganisms presences of Polyester Fabric (Univariate Analysis)**

Antimicrobial			Plant Extract			
	Df*	SS*	MS*	F	P	$\eta^2$
Between-group	3	18.00	6.00	4.615	.013	.409
Within-group	20	26.00	1.30			
Total	23	44.000				

\*DF= degree of freedom, \*SS= sum of squared differences from the mean, \*MS= Mean Square

*A. indica* and *B. monosperma* and *L. chinensis* plant extracts had effect on microorganism for polyester fabric as compared to control group also shown in Table 3.

**Table 3: Effect of Antimicrobial finish on Microorganisms presences of polyester fabric**

Plant Name				Mean Difference (I-J)			Std. Error	Sig. <sup>b</sup>
Microorganisms presences	Control vs Experimental ( <i>A. indica</i> )			2.000			.658	.006
	Control vs Experimental ( <i>B. monosperma</i> )			2.000			.658	.006
	Control vs Experimental ( <i>L. chinensis</i> )			2.000			.658	.006
	Control Group		<i>A. indica</i>	<i>B. monosperma</i>		<i>L. chinensis</i>		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	2.00	2.28	.00	.00	.00	.00	.00	.00

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One Way ANOVA shows difference in antimicrobial finish between control group (M=2.00, SD=2.28), the first experimental group *A. indica* (M=.00, SD=.00), second experimental group *B. monosperma* (M=.00, SD=.00) and third experimental group *L. chinensis* (M=.00, SD=.00) were statistically significant (F=4.615, p=0.013,  $\eta^2=.409$ ). It reveals that control group scored significantly higher than the experimental groups. However the three

experimental groups (*A. indica*, *B. monosperma* and *L. chinensis*) did not differ significantly. The significant difference between control group and the experimental group is also evident from the big difference in the mean values and remarkable difference in standard deviation (control=2.28, *A. indica*=.00, *B. monosperma* =.00, *L. chinensis*=.00). The antimicrobial finishes made a significance difference on polyester fabric for microorganism's colony also shown in Table 4.

**Table 4: Colony Characteristics**

Pigments		Microscopy Structure	Surface	Colony Form	Elevation	Margins
<b>Untreated fabric samples</b>						
Polyester	Orange	Gram -ve Short thin rods	Smooth	Circular	Raised	Entire
Polyester	Yellow	Gram -ve Coccus	Rough	Irregular	Flat	Curled
Polyester	Yellow	Gram -ve Coccus bacilli	Rough	irregular	Flat	Serrate
Polyester	Yellow	Gram -ve Coccus	Rough	Irregular	Flat	Serrate
Polyester	Off white	Gram +ve Cocci cluster	Smooth	Circular	Flat	Entire
Polyester	Yellow	Gram -ve Coccus	Rough	Irregular	Flat	Serrate
Polyester	Orange	Gram -ve Coccus	Rough	Irregular	Flat	Serrate

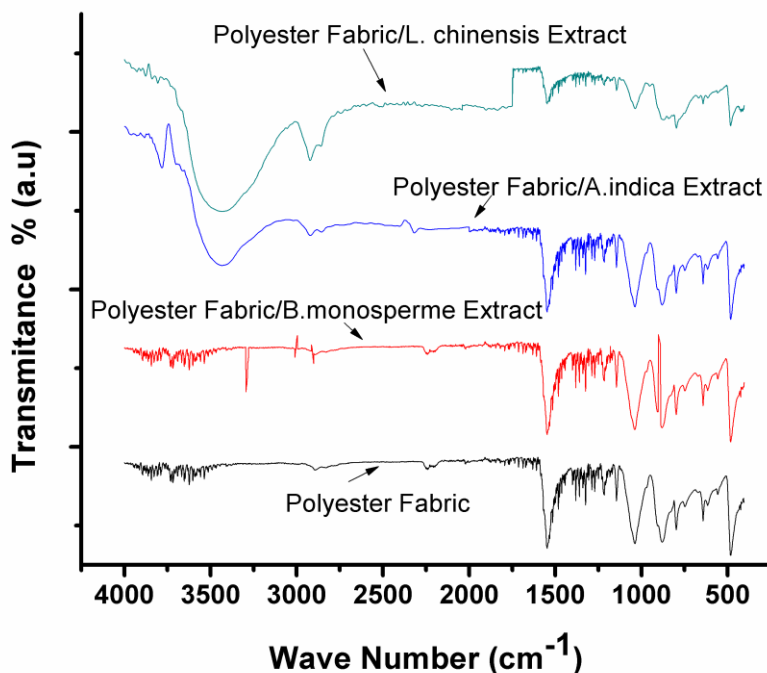
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There were 8 colonies on untreated polyester fabric. On untreated (control group) fabric microorganisms presences was shown while on treated fabrics no colony was shown. The microorganisms that was observed were Gram +ve small thick rods, cluster, cocci, coccus cluster and Gram -ve such as thin short rods, diplococcal short tail rounded, coccus, cocco bacilli, coccus diploid bacteria and fungus (yeast). The microbes observed during the experiment was on untreated fabric gram +ve (small thick oval rod, cocci cluster, thick short rods with rounded ends), gram -ve (diplococcal short tail rounded, short

thin rod, coccus, coccus bacilli) and fungus were observed. So, Study make percentage reduction against microorganisms.

The FTIR spectrum of polyester fabric is shown in Fig 1. The high peak from  $1700\text{ cm}^{-1}$  to  $600\text{ cm}^{-1}$  indicates the original signals, such as characteristics spectra of stretching vibration band of C=O at  $1730\text{ cm}^{-1}$  and O-C-O stretching vibration band at  $1097\text{ cm}^{-1}$  and  $1240\text{ cm}^{-1}$ . All these peaks confirm the existence of ester linkage. A broad band region  $3435\text{ cm}^{-1}$  which shows the presence of hydroxyl group.

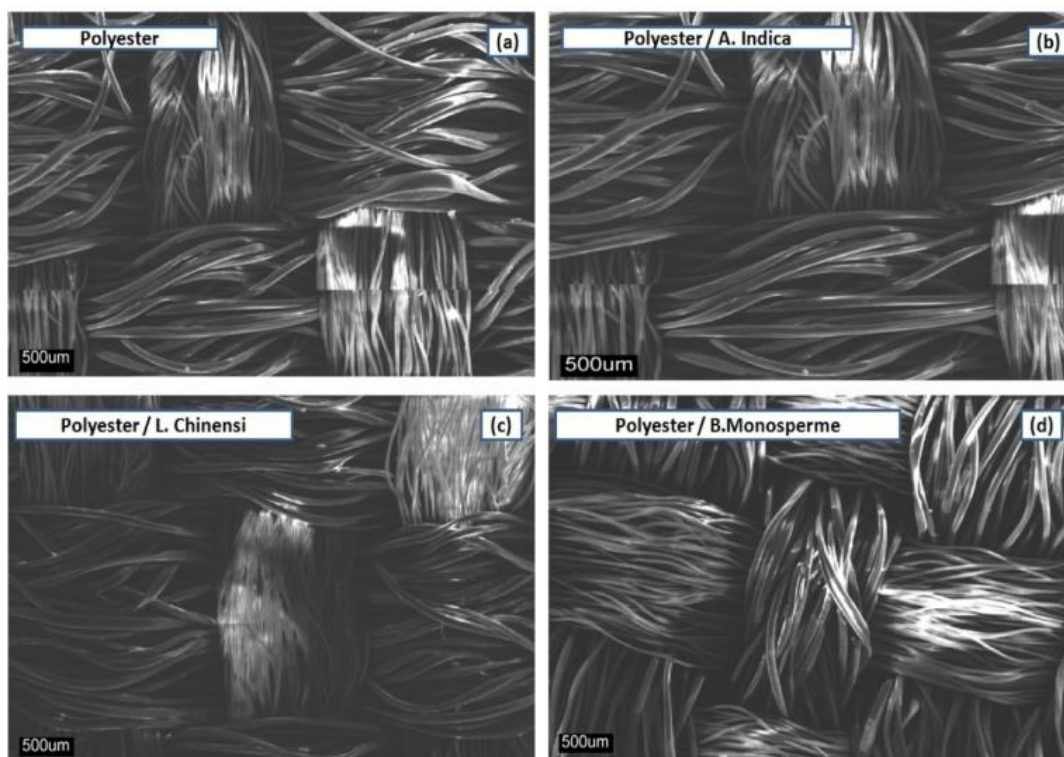
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**Fig. 1. FTIR Spectra of untreated vs treated polyester fabrics**

Fig. 2 showed the outcome of treatment of extract on polyester fabric. Fig. 2a is the SEM illustration of pure polyester, Figure 2b is *A. indica*, Figure 2c is *L. chinensis*, and Figure 2d is *B. monosperma* processed polyester fabric. It is revealed that with the dealing of extract on polyester fabric is unaffected

for the structure of woven polyester fabric expect the *L. chinensis* in which little bit of breakage is appear on the surface of the fabric. The treated polyester fabric treated shows presence of finish as compare to untreated fabric. The result indicates that hypothesis is not accepted.



**Fig. 2. SEM micrographs of untreated and treated polyester fabric**

## DISCUSSION

The eco-friendly antimicrobial finishes were developed from leaves of *A. indica*, *B. monosperma* and *L. chinensis*. The antimicrobial finish was applied by pad dry cure method on 100% polyester. The results were tested in comparison of untreated fabric (control group). The readings were taken after 22 hours as mentioned in ASTM 2149 shake flask method, and after six days to check the effectiveness of antimicrobial finish. The microbes which were observed during the experiment on untreated fabric were gram +ve (small thick oval

rod, cocci cluster, thick short rods with rounded ends), gram –ve (diplococci short tail rounded, short thin rod, coccus, coccus bacilli) and fungus while no microbial growth found on experimental group.

In other study Neem oil was extracted from leaves of neem plant (*Azadirachta indica*) and used for making antimicrobial finish. Study reported the extraction and characterization of a surfactant from neem oil (SNO). It displayed a yield of approximately 100%. It showed suitable detergent characteristics with a high potential to

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be use as a cleansing agent for textile applications, such as high pH value (10.1), suitable foaming of 1.5 cm and a critical micelle concentration of nearly 0.12 g mL<sup>-1</sup>. The surfactant from neem oil (SNO) showed a moderate bactericidal activity against *Escherichia coli* and bacteriostatic activity against *Staphylococcus aureus*; both are common social pathogens. This presents that surfactant from neem oil (SNO) has a good potential to be used in medical textile applications due to its detergent and bactericidal properties (Siqueira et al., 2021).

Another study found that organic antibacterial reagents had long-term biocidal effects without being hazardous to the environment. Due to their specific targets of action, small molecular antibiotics can cause the emergence of microbial resistant species; however, in the case of the currently described antimicrobial reagents, physically destroying microbial cell membranes is reported as main route for preventing microbial growth (Darwesh et al., 2018). Organic antimicrobial finishing compounds (natural and synthetic in origin) have been extensively depicted as one of the primary classes of antimicrobial textile finishing agents in this review. Textile antimicrobial compounds derived from natural sources, such as chitosan, cyclodextrins, and natural colours, were found to be environmentally friendly (Emam, 2019).

In another study polyester/aluminum (PET/Al) filter were used as a highly efficient simultaneous capture of microbe and inactivation of airborne microorganisms that settle on fabric for several days (*E. coli*, that can settle for 21 days on polyester fiber). In this study nanograins were grown on the fibers and the antimicrobial activity against airborne *E. coli* and *S. epidermidis* was tested. It was approximately 94.8% and 96.9% respectively, due to the reinforced hydrophobicity and surface roughness of the filter (Choi et al., 2018).

Triclosan is strong alternative for antibacterial function against microorganisms in textiles including medical applications, such as face masks, lab coats, and wound dresses. It increases the characterization, antibacterial properties and durability of triclosan on polyester, polyester/cotton, and cotton surfaces. The pure triclosan and presence of triclosan in solutions was detected by gas chromatography and mass spectrometry chromatograms. In this, surfaces were homogeneously covered by triclosan on scanning electron microscope micrographs, and there were new bands on Fourier transform infrared spectra after treatments. Triclosan shows strong biocidal activity to bacteria for 3 hours. Although they lost their antibacterial properties after washing, but they showed good antibacterial (bactericidal)

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properties and also long durability to washes. It showed that triclosan is a highly effective and durable chemical on polyester and cotton surfaces for medical textile applications. Triclosan was presents long-term activity against *S. aureus* and *E. coli* of about  $10^5$  colony-forming unit (CFU)/mL, even at a lower concentration, while the untreated surfaces did not show any antibacterial activity (Orhan, 2020).

Another investigation discovered that natural antibacterial reagents had long term biocidal impacts without being dangerous to the climate. Because of their particular focus on activity, little sub-atomic and anti-infection agents can cause the development of microbial safe species (Gressier et al., 2019). However, on account of evaluated antimicrobial reagents, annihilating microbial cell films are accounted to be the principal course for forestalling microbial development. Natural antimicrobial completing mixtures (regular and engineered in beginning) have been broadly depicted as one of the essential classes of antimicrobial material in this study (Joshi et al., 2009). Antimicrobial mixtures from natural sources, were observed as harmless to the ecosystem (El-Khatib, 2012).

### CONCLUSION

The increase demand of polyester fabric attracts the attention of textilers and researchers towards antimicrobial finishes. Currently in the world

antimicrobial finishes are applying in textile industry, that are made of synthetic and metallic antimicrobial agents that may cause allergy, skin disease. Antimicrobial finishes should be cost effective and eco friendly for use of every textiler. In this research, antimicrobial finishes were obtained from plant leaves named *A indica*, *Butea monosperma* and *Litchi chinensis*. In this method, extraction of plant leaves, their grinding, wetting, soaking and filtering do not demand heavy apparatus. It was concentrated by rotatory evaporator. The presence of antimicrobial finishes on fabric was checked by ASTEM shake flask method. All three antimicrobial finishes do not allow any microbial colony to grow on polyester fabric. However in control group, eight different colonies were observed. So it was concluded that these organic antimicrobial finishes should be use in textile industry.

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### CONFLICT OF INTEREST

The authors declared no conflict of interest.

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