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Eco-Friendly Antimicrobial and UV Protection Functional Finishing of Cotton and Bamboo Fabric using Tulsi (Ocimum sanctum)

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Abstract: ***In the present pandemic scenario, the new quality textile requirements not only emphasize on the intrinsic functionality and long service life of the product but also functional finish processes that should be environment-friendly. This study deals with extraction of Tulsi (Ocimum sanctum) leaves using water and methanol. The Tulsi (Ocimum sanctum) have been applied to cotton and as well as on Bamboo fabric in presence and absence of free formaldehyde crosslinking agent (Glyoxal) using Pad-Dry-Cure method. Antimicrobial properties of treated fabric have been improved which make it more important and inevitable finish for Garments. The Treated cotton and Bamboo fabric have shown an excellent antimicrobial activity. The sample were examined of colour strength value and cotton and Bamboo treated fabric show very good results for UV protection. The novel feature of this study was the use of FT-IR spectroscopy to identify the major chemical groups in the extract as well as its attachment on cotton and bamboo.***

Keywords: Tulsi (Ocimum sanctum) leaves, Antibacterial, Eco-friendly finishing, Herbal extract, cotton and Bamboo fabric

1. Introduction

Textiles are natural polymers of vegetable origin. It has been produced for human, to cover their bodies for temperature, dust, sunlight, wind and external environmental atmosphere. Apparel has an important place in human life, from old time till now through developing newer high technology and interdisciplinary products. Plants and plant product are traditionally used for healing of wounds, burn injuries, anti-fungal, anti-viral, anti-bacterial, UV-protection and anti-microbial activity against skin infections. Herbal plant extract for antimicrobial finishing in textiles because of the excellent antimicrobial and eco-friendly properties exhibited by them.

Nowadays, among the environmental pollution, it is important to develop or find new hygiene products. Nowadays the consumers are demanding eco-friendly products. Hence the research has been carried out to use natural herbal plant extracts for antibacterial and UV-protection finishing in textiles. The antimicrobial bioactive agents have become highly important for bio-functionalization for textile materials because they impart safe non-toxic and environment-friendly properties. Many plant extracts possessing antibacterial properties can be used as textile finishing agents. [1]

Tulsi (Ocimum sanctum) is a holy plant of Indian origin. Tulsi (Holy Basil) belongs to the Lamiaceae family, and the botanical name is Ocimum Sanctum. Tulsi is also called as queen of herbs which shows numerous medicinal properties in herbal drugs. Genus Ocimum contains more than 30-160 species including Ocimum tenuiflorum (holy basil), Ocimum gratissimum (African basil), Ocimum SanctumLinn (Tulsi), Ocimum Americanum [2]. Tulsi has been used for thousands of years in Ayurveda for its diverse healing properties. Ocimum sanctum (Family Labiatae) is a many branched, erect, stout and aromatic herb about 75 cm high. It is erect, branched fragmented shrub with the height of about 30- 60cm when mature. Tulsi has biologically active compounds are ursolic acid, rosmarinic acid, oleanolic acid, eugenol (70%), methyl eugenol (20%), carvacrol (3%), linalool, caryophylin, and βcaryophyllene [3]. Ocimum sanctum is mainly responsible for the therapeutic effect of tulsi. Antimicrobial activity of tulsi is due to its constituents,activity are camphor, eucalyptol and eugenol [4].

Tulsi in various ingredients to the different parts of plants and stem as well as leaves hold a variety of constituents such as saponins, triterpenoids, flavonoids, and tannins and leaf volatile oil contains eugenol [5]. Tulsi leaves protective action for coughs, bronchitis, skin diseases, and therapeutic action of Tulsi seeds for curing ulcers, emesis, tiredness [6]. Thilagavathi et al. [7] has reported that observed Tulsi leaves having antimicrobial activity are suitable for textile application. Methanolic extracts of Tulsi leaves applied on cotton fabric by dipping method. In this study, Tulsi did not show any activity, it exhibited a bacterial reduction of 73% in challenge test [7]. The bacteria-resist properties of Tulsi oil have been studied by Sarkar et al. [8] has reported that the oil added to the size paste as size preservative for application on cotton yarn in lea form but it did not produce any encouraging results after storage of the sized leaves from the strength retention point of view [8].

This research discusses the application of Tulsi (Ocimum sanctum) extract herbs on the cotton and Bamboo fabric in absence or presence of eco-friendly crosslinking agent (glyoxal) to help fixed it on the fabric, which in turn increase durability of treated cotton as well as on Bamboo fabric to the desired properties, via herbs treatment.

2. Material and Experimental Method

2.1 Material

The desized, scoured and bleached cotton and Bamboo fabric and purchased from local market were used for the study. The fabric was purified by scouring at 100 ^{0}C for 60 min. using a solution containing Na_2CO_3 (2g/l, wetting agent, 1%), to remove dust particles and finishing chemicals, then all the fabric were neutralized, thoroughly washed with water and dried at ambient conditions.

2.2 Methods and procedures

2.2.1 Extraction of Tulsi (Ocimum sanctum)

Tulsi (Ocimum sanctum) leaves Firstly Collected form the plant and washed with water. The leaves were dried at 60-80 ^{0}C for short time in laboratory oven, so that the volatile contents are not lost. Dried Leaves were converted to fine power by grinding.
Two extraction Techniques were used to extract from the Tulsi (Ocimum sanctum) Powder.

1) Water Extraction: The 10gm dried Tulsi (Ocimum sanctum) were Soaking in required volume of 100ml water for overnight. This mixture is obtained Brown coloured solution are shown in figure 1 (a) and filtered through wattmam filter paper no.1. finally, the total volume of extract was increased to 100ml with distilled water. This solution was used as stock solution of 10:100 strength.

2) Methanolic Extraction: In the case of methanolic extraction 10 gm of obtained powder of dried Tulsi (Ocimum sanctum) was extracted in 100 ml of methanol. The powder soaking in methanol was overnight, this mixture is obtained green coloured solution are shown in figure 1 (b) the extract was filtered through wattmen filter paper no.1. This extract was used as stock solution of 10:100 strength.

(a) Water Extraction **(b) Methanolic Extraction**

Figure 1: Tulsi (Ocimum sanctum) Extraction Through Obtained Coloured

2.3 Cotton and Bamboo Fabric Treatment with Tulsi (Ocimum sanctum)

The cotton and Bamboo fabric was treated with the product of the two extract methods (aqueous or methanol extract method). This treatment was done in absence or presence of eco-friendly crosslinking agent. Firstly, the cotton fabric as well as Bamboo fabric was treated with herbal extract by Pad-dry-cure method. Then the finished cotton fabric was subjected for the antimicrobial assessment. Secondly, the cotton and Bamboo fabric was treated with the two previous herbal extract in presence of eco-friendly crosslinking agent as follow: 2% of herbal extract was mixed with 6% of glyoxal as crosslinking agent and 4% aluminum sulphate $Al_2(SO_4)_3$ was added as a catalyst. Cotton fabric was padded dip and nip in the finishing formula and then the treated fabric was dried at 80°C for 5 min. and cured at 120 °C for 3 min.

Cross-linking: Usage of cross-linkers to create covalent intermolecular bridges between polymer chains.

2.4 Characterization of treated fabric

Evaluation of Dyed Samples. The dyed samples were assessed for $L*$ $a*$ $b*$ colour coordinates and K/S values (illuminate D65/10^0 observer) on spectra scan 5100 (RT) spectrophotometer (Premier Colour scan Instrument). The antibacterial activity was checked against both Gram positive bactria and Gram negative bacteria according to Test Methods as per AATCC - 147 for E.Coli and Bacillus subtilis (Agar well diffusion method). Ultraviolet protection factor (UPF) optimum treated and untreated sample was analysed using UV-2000F instrument make lab sphere were used for this purpose in the UV wavelength range (290 to 400nm). IR spectra of untreated and treated fabric samples were structural analysis in Shimadzu FTIR 8300 infrared spectrometer.

3. Results and Discussion

The Cotton and Bamboo fabric sample were prepared for dyeing then dyed with Reactive dye (Coracion Blue HERD) and then Finished with Natural Bioactive Agent choice. The dyed sample were subjected to finishing with natural bioactive agent Finishing Choice for work Tulsi (Ocimum sanctum). This finished samples were analysed to study the antimicrobial and UV-Protection Functionality. The results include the evaluation of various of functional properties including antimicrobial and UV-Protection with the help of colour Strength Value and structural analysis of the sample obtained using various variables.

3.1 Effect of Natural Bioactive Finishing Techniques on Colour Strength Value (K/S Values)

The Cotton and Bamboo being a Cellulosic material can be dyed with Coracion Blue HERD Reactive dye then finishing with natural finishing agent such as Tulsi (Ocimum sanctum). The control sample is considered dyed fabric is considered before finishing.

Table 1 represents the results in terms of colour co-ordinates and colour strength (K/S values) of samples dyed with and without mordant. From Table 1, it can be seen that cotton fabric can be dyed with all three natural extracts. In all cases, the colour co-ordinate value (L *, a*, b* Values) shows the colour and shade of the dyed fabric, where L* represents, lightness/darkness; a*, the red/green values; and b*, the yellow/blue value.

Table 1: Colour strength (K/S Values) and Colour co-ordinates of Tulsi bioactive finishing on Cotton and bamboo

Sr. No.	Sample code No.	Cotton				Bamboo			
		Colour strength (K/S Values)	Colour co-ordinates			Colour strength (K/S Values)	Colour co-ordinates		
			L*	a*	b*		L*	a*	b*
1	Control	2.414	49.75	-8.56	-17.95	1.894	51.51	-7.60	-14.44
2	T.W 1	1.728	46.32	-9.83	-2.77	1.581	49.22	-12.57	3.77
3	T.W 2	1.853	45.54	-11.94	1.84	1.531	49.04	-13.51	6.50
4	T.W 3	1.835	45.80	-10.58	-0.84	1.575	49.35	-12.07	2.99
5	T.W 4	1.908	47.15	-13.71	1.11	1.603	49.31	-12.05	3.56
6	T.M 1	2.061	42.11	-6.47	13.34	3.230	43.91	-5.07	16.47
7	T.M 2	2.251	42.65	-4.73	15.28	5.230	43.76	-3.06	16.79
8	T.M 3	2.461	41.17	-4.68	13.63	4.361	42.85	-3.34	13.85
9	T.M 4	2.892	42.96	-4.47	14.67	5.754	43.99	-4.02	17.89

NOTE: T.W- Tulsi water Extraction treated sample, T.M- Tulsi methanolic Extraction treated sample**,** Here is described to parameters of the Concentration, Time, Temperature in numbers. Were, **1**- 20% Conc., 60 min, 80 ^{0}C, **2**- 30% Conc., 30 min, 80 ^{0}C, **3-** 30% Conc., 60 min, R.T (35-40 ^{0}C), **4-** 30% Conc., 60min, 80^{0}C.

Observation of above table in clearly indicate that cotton as well as Bamboo fabric sample on Colour Strength value and Colour co-ordinates value of T.W Treatment in higher is T.W 4 at 30% Conc., 60 min, 80 ^{0}C. and Lower at T.W 1 at 20% Conc., 60 min, 80 ^{0}C. The control dyed fabric has colour strength value is higher than T.W 1, T.W 2, T.W 3 and T.W 4 on both Cotton and Bamboo fabric. and T.M treatment on cotton and bamboo fabric were results are shown in table 1 in higher colour strength value is T.M. 4 at 30% Conc., 60 min, 80 ^{0}C. and lower colour strength value at T.M 1 at 20% Conc., 60 min, 80 ^{0}C. In Water and methanolic extracts of Tulsi Bioactive agent the colour strength value was increased methanolic extract to compared control Reactive dyed sample of cotton and bamboo fabric.

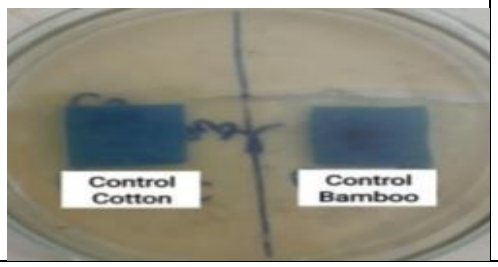
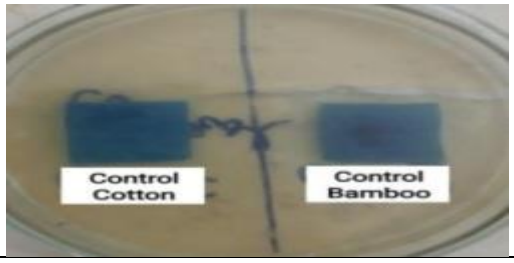
3.2 Qualitative Evaluation of the Anti-Bacterial Activity of the Cotton and Bamboo Fabric

The control sample is considered dyed fabric is considered before finishing. The sample after finishing with various bioactive agent mention earlier under different condition described is earlier. The cotton and bamboo fabric sample were Finishing with Natural Bioactive agent are Tulsi (Ocimum sanctum). The antibacterial activity of treated fabric was evaluated quantitatively by measuring the number of colonies of Bacillus subtilis (Gram-positive) and E. coli (Gram-negative) as per the test method of Qualitative assessment of the antibacterial activity of the treated cotton and bamboo fabrics were carried out by Parallel Streak Method (AATCC 147).

The effects of the plant extracts against both gram positive, gram-negative bacteria was depending on components type in the plant extract. Recently, many researchers have studied the mechanism of the antimicrobial effect on textiles fibres, and indicated that the fibre surface bonded to antimicrobial agents, which disrupt the cell membrane of the microorganisms by an electrochemical mode of action [8, 9].

Tulsi belongs to Labiatae generic group of herbs. Its leaves contain 70% eugenol, 3% carvacrol, 20% methyl eugenol and small amount of β-caryophyllene and oleanolic acid. It has been studied that these ingredients serve excellent against certain bacteria, molds, mildews, microbes and insects. These compounds are supposed to minimize the bacterial growth up to 73% in various studies. Tulsi results better on cotton and Bamboo fabric in reducing the growth of bacteria. In a comparison of tested bacteria, high inhibition zone was detected for Bacillus than Escherichia coli [10].

The zone of inhibitions obtained in the different treatments was observed and illustrated in Tables 2 and figure 2. The untreated sample of cotton and bamboo has no antimicrobial activity was found. Therefore, antimicrobial activity for the Tulsi treated crosslinking with Glyoxal used of concentration of 6 o.w.f (on the weight of the fabric), and aluminium sulphate ate concentration of 4 o.w.f (on the weight of the fabric) are the optimum concentrations for both the cotton and bamboo fabrics used.

Sample	Bacillus (gram-positive)	E. coli (gram-negative)
Control		

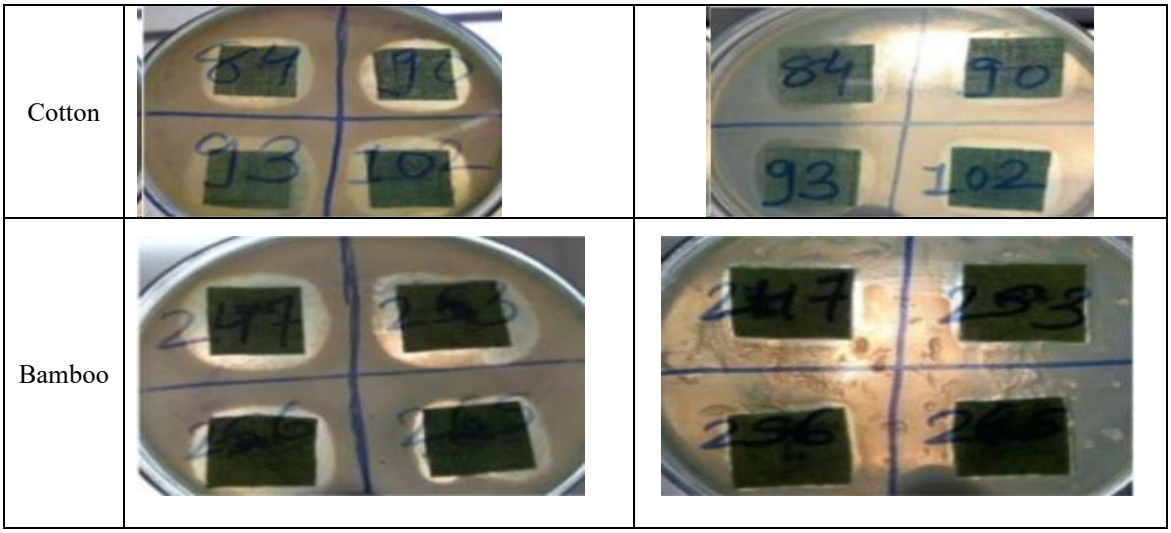


Figure 2: Evaluation of the Anti-Bacterial Activity of the control dyed sample and finished with natural bioactive agent of Tulsi (Ocimum sanctum) of cotton and bamboo fabric by AATCC Test Method

Table 2: Effect of natural bioactive extracts of Tulsi (Ocimum sanctum) on cotton and bamboo the bacterial activities

Sr. No.	Sample code No.	Cotton		Bamboo	
		Zone of inhibition "W" (mm)		Zone of inhibition "W" (mm)	
		Bacillus (Gram Positive)	E. coli (Gram negative)	Bacillus (Gram Positive)	E. coli (Gram negative)
1	Control	-	-	-	-
2	T.W 1	27	24	22	22
3	T.W 2	27	25	24	22
4	T.W 3	29	25	24	21
5	T.W 4	35	26	31	27
6	T.M 1	27	21	29	22
7	T.M 2	27	26	26	23
8	T.M 3	23	22	24	20
9	T.M 4	35	27	36	26

The control cotton and bamboo fabric sample found to have no antibacterial activity with zero area. Zone of inhibition detected in treated fabric specimen against both bacteria in (table 2 and also Figure 2) increases with increase in concentration of complex mixture of natural bioactive agents. This clearly indicates that cotton and Bamboo acquires antibacterial activity as a result of treatment with natural bioactive agents of Tulsi (Ocimum Sanctum) and protection against both bacteria enhanced drastically with increase in concentration. The Water extract of Tulsi (Ocimum sanctum) agent Against bacteria Bacillus (gram-positive), zone of inhibition increases from 27 to 35 mm on cotton and zone of inhibition increases from 22 to 31 mm on Bamboo with increase in concentration from 20 to 30%. Similarly, an increase from 24 to 26 mm on Cotton and increase from 22 to 27 mm on Bamboo fabric sample was observed against bacteria E. coli (gram-negative) under the same conditions. The methanolic extract of Tulsi (Ocimum Sanctum) agent Against bacteria Bacillus (gram-positive), zone of inhibition increases from 27 to 35 mm on cotton and zone of inhibition increases from 29to 36 mm on Bamboo with increase in concentration from 20 to 30%. Similarly, an increase from 21 to 27 mm on Cotton and increase from 22 to 26 mm on Bamboo fabric sample was observed against bacteria E. coli (gram-negative).

3.3 Ultraviolet (UV) Protection Factor

The ultraviolet protective factor (UPF) is a numerical value which represents the degree of protection against UV rays provided by clothing. It is defined as the ratio of the amount of time needed to produce damage on skin protected with a textile material to the amount of time needed to produce such damage on unprotected skin [11]. The ultraviolet radiation band consists of three regions: UV-A (320 to 400 nm), UV-B (290 to 320 nm), and UV-C (200 to 290 nm). UV-C is totally absorbed by the atmosphere and does not reach the earth. UV-A causes little visible reaction on the skin but has been shown to decrease the immunological response of skin cells. UV-B is most responsible for the development of skin cancers. The UV radiation transmission, absorption and reflection are responsible for the UV protection ability of a fabric. [12, 13].

Ultra Violet Protection Factor (UPF) is measured on natural Bioactive finishing sample using standard method EN ISO 13758-1:2002 by lab sphere UV-2000F Ultra transmittance analyser. Observation of table 3 it is clearly that all treatment which describe above restricts the UV Blocking in the region between 260 nm to 440 nm in all the fabric. The UPF is strongly dependent on the chemical structure and other additives present in the fiber. A high correlation exists between the UPF and the fabric porosity but it is also influenced by the type of the fibers.

Sr. No.	Sample code No.	UVA blocking %	UVB blocking %	MEAN UPF	Calculated UPF rating	Protection Category
1	Control Cotton	24	18.8	10.08	4.2	No Protection
2	Control Bamboo	47.13	44.75	42.40	24	Good Protection
3	T. M Cotton	71.276	67.829	60.58	32	Very good Protection
4	T. M Bamboo	78.225	75.652	72.23	42	Excellent Protection

Table 3 indicate the effect of light exposure on UPF values, percentage UV Blocking for control and methanolic extract natural bioactive agent through finished treated cotton and Bamboo fabric sample. The calculated UPF value of Control cotton fabric 4.2 so, it is not protection against UV-Radiation. The UPF of Tulsi (Ocimum sanctum) methanolic extract through finishing Cotton fabric Sample T.M has UPF rating about 32. The calculated UPF value of Control bamboo fabric 24 so, it is good protection against UV-Radiation. The UPF of Tulsi (Ocimum sanctum) methanolic extract through finishing bamboo fabric sample T.M has UPF rating about 42.

Observation of results indicates bamboo fabric is given greater protect to ultraviolet irradiation compare to cotton fabric. Because of count of cotton fabric is low and also it is produced higher transmittance of UV rays compared to bamboo fabric [14].

3.4 Fourier Transform Infra- Red (FTIR) Analysis

The Infra-Red (IR) spectra of selected sample (untreated and treated) were recorded on single beam Shimadzu FTIR 8300 Spectrometer using a resolution of 4 cm. A potassium bromide (KBr) pellet technique was employed. The sample was ground with KBr for 15 min in order to obtained finely dispersed mixture. A pellet was passed from this mixture and the spectrum of fibre sample, was recorded.

IR Spectroscopy of various Treatment on Cotton and Bamboo sample

1) Untreated (Dyed samples)
2) Tulsi Water Extract (T.W)
3) Tulsi Methanolic Extract (T.M)

Was carried out in region of 3500 cm^{-1} to 500 cm^{-1} and the spectra are shown in figure 3 and 4 respectively. These spectra were analysed based on band assignment. It is well known that the IR absorption gives information about atomic vibration frequencies and is closely related to type of chemical bonds present.

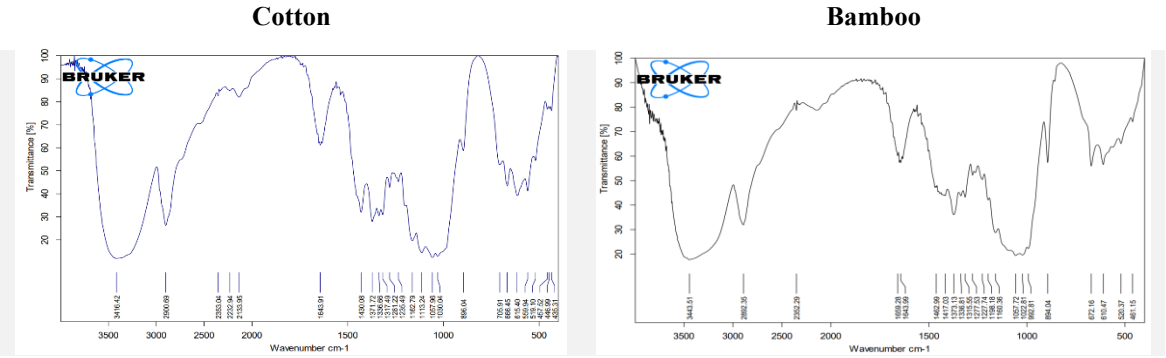


Figure 3: FTIR spectrum of untreated Cotton and Bamboo Fabric

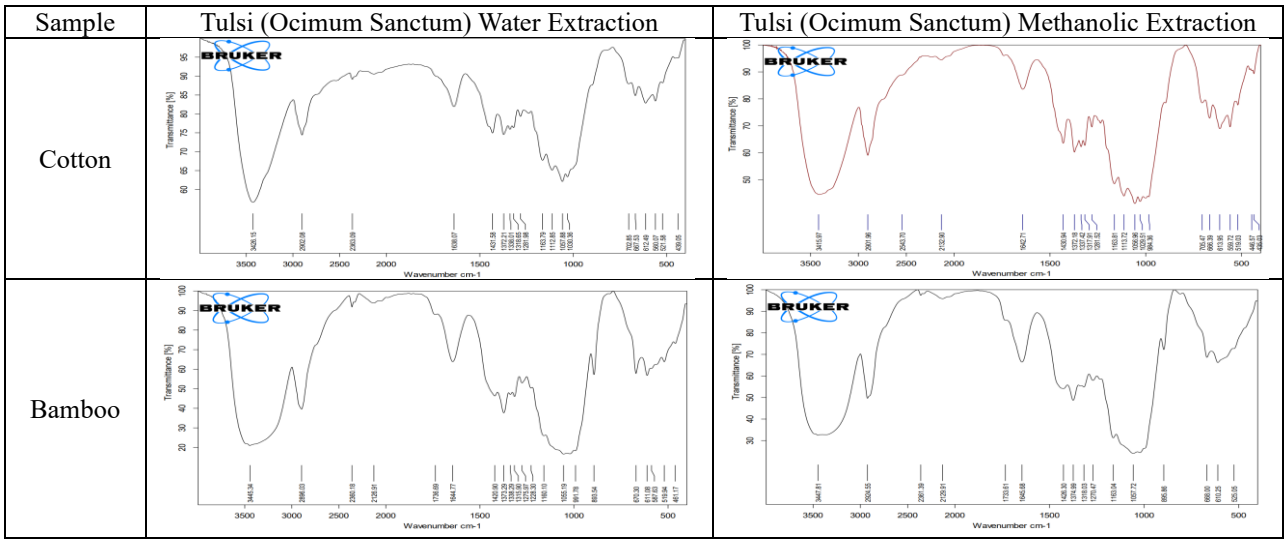


Figure 4: FTIR spectrum of Cotton and Bamboo fabric Treatment with Tulsi (Ocimum Sanctum) Water and Methanolic Extract

Form above observation figure 3 and 4 of change in intensity and position of various picks in different sample we can say that the change in a pick corresponding to a particular component indicates the change in composition of the particular component. So, compared to untreated fabric the position of picks in conventionally as well as treated sample indicates. The strong absorption band was seen near at 3416.42 cm^{-1}, indicate stretching of -NH stretch of amino groups –OH group mainly from phenolic groups. The peaks at 2900.69 cm^{-1} are due to the C-H stretching of alkanes compounds. The absorption peaks near at 2232.94 and 2133.95 cm^{-1} C≡N stretching of nitriles and –C≡C– stretching of alkynes. The absorption band nearer to 1643.91 cm-1is indicates the presence of - C=O and -C=C- stretch respectively of aromatic rings. The absorption band near at 1430.04 cm^{-1} is C–H bend of alkanes. The FT-IR peak near at 1235 cm^{-1} in dictated about C-N stretching. Weak adsorption band nearer to 1,000 cm^{-1} indicates presence of ether linkages. The bamboo fabric is treated with Tulsi (Ocimum Sanctum)water and methanolic extract in show the peak at 2126.91 cm^{-1} C≡N stretching of nitriles and the Tulsi (Ocimum Sanctum) both water and methanolic and the peak of 1736.69 cm^{-1} C=O stretching of esters, saturated aliphatic.

4. Conclusions

The essential aim of the present study was the exploration of anti-microbial and UV-Protection properties of Tulsi (Ocimum Sanctum) extracts applied through Pad-Dry-Cure method ocotton and Bamboo fabric, advent a new technology in consumer needs. The net results of this study were showed that the specimens treated with the extract in presence and absence of crosslinking agent have excellent disinfection properties. The treated sample showed high decrement in colonies grown and a clear zone of bacteria inhibition for crosslinking fabric than the other.

The Tulsi (Ocimum sanctum) of Natural bioactive extract finishing of three different Parameters are concentration, Time and Temperature is increased, when the colour strength (K/S Value) is also increased on cotton and Bamboo. The water and methanolic extract finished at parameter of 30% conc., 60 min, and 80 ^{0}C is gives better results than all others are obtained it on both cotton as well as Bamboo material. The coloured obtained on two substrates is different in both extraction method. The methanolic extraction method of Tulsi (Ocimum Sanctum) gives green coloured and water extraction gives brownish coloured.

The cotton and bamboo, the given result of Bacillus (Gram Positive) zone inhibition is better than that E. coli (Gram negative). It means that bacterial species belong to gram positive has high rate of inhibiting growth as compared to the gram negative. The results depicted that the treated sample slowdown the growth of gram-positive bacteria for about 92% than untreated samples. The conclude that when increase percentage (%) of concentration, Time and temperature with increased zone inhibition in both Gram positive and Gram Negative on Cotton and Bamboo fabric. The cotton fabric treated with Tulsi (Ocimum Sanctum) methanolic Extract gives protection against UV radiation in very good category. The bamboo fabric treated with Tulsi (Ocimum Sanctum) methanolic Extract gives protection against UV Radiation in Excellent category.

The Changes take placed at micro level as a result of conventional as well as functional finishing processing were analysed through Infra-red Spectroscopy. FTIR analysis investigated the presence of mainly compounds in tulsi (Ocimum Sanctum) water and Methanolic extract which is known to have Antibacterial and UV-protection properties giving on Cotton and Bamboo.

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