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Short Communications

Use of essential oils as bioactive substances for antimicrobial finishing of fabrics

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Antimicrobial compounds (essential oils) have been extracted from natural spices, such as oregano and cinnamon, using organic solvent (ethylene) by soxhlet apparatus. The above bioactive agents (5% & 10 % owfseparately for both agents) are applied separately on plain cotton and polyester/cotton woven fabrics using pad-dry-cure process. For fixation of the finishing agents, glutaraldehyde (8% owf) has been used as a cross-linking agent along with sodium hypophosphite (2% owf) as the catalyst. Evaluation of the antimicrobial activity of untreated and treated fabrics has been performed quantitatively by percentage reduction test against test organisms Gram-positive bacteria *Staphylococcus aureus* and Gram-negative bacteria *Escherichia coli*. The results indicate that treated fabrics register >90% antimicrobial activity against *S. aureus* and *E. coli* bacterial strains. After 10 washes, the efficacy of antimicrobial activity is reduced by 10-20% only. A small decrease in flexibility, breaking strength and elongation properties is observed for treated fabrics. However, treated fabrics show enhanced crease recovery.

Keywords: Antimicrobial activity, Bioactive substance, Biodegradable, Cotton, Polyester/cotton fabric

Cross infection by pathogens leads to the development of odour when the fabric is worn next to the skin. As consumers are increasingly aware of a hygienic lifestyle, there is a necessity for the development of a wide range of textile products finished with antimicrobial properties. Apart from this, microbial attack can cause discolouration and loss of functional properties of fabrics, and hence prevention of microbial attack on textiles has become a matter of significant importance. In view of this, to prevent the development of objectionable odour, dermal infection and other related diseases and to prevent product deterioration, antimicrobial finish is applied to textile materials[1].

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A variety of antimicrobial textile materials have been reported till date. Chemical-based antimicrobial agents are synthetic non-biodegradable chemical compounds, which cause environmental and health concerns. The finishing ingredients used in antimicrobial finishing need to be effective, selectively active towards harmful microbes, bioactive, non-toxic, biodegradable and permanent[2]. Natural extracts from various parts of some of the medicinal plants and herbs exhibit antimicrobial properties. These antimicrobial compounds are mostly extracted from plants, such as aloe vera, tea-tree, eucalyptus, neem, tulsi leaf, etc[3]. The textile products treated with these natural plant extracts are required to be reusable and durable antimicrobial textiles, which are effective against harmful pathogens. Such products will be beneficial for both medical industry workers and the general public as well. Spices and herbal plant extracts exhibit antimicrobial activity. The main components present in these natural antimicrobial agents such as basil, thyme, and oregano essential oils, are linalool, thymol, and carvacrol respectively, which exhibit antimicrobial activity against various microorganisms.

In this study, the antimicrobial functionality of cotton and polyester/cotton fabrics finished with extracts of spices, such as oregano and cinnamon, has been investigated. According to Conner *et al*[4], the antimicrobial action of essential oils may be due to the impairment of a variety of enzyme systems including those involved in energy production and structural component synthesis of harmful microorganisms. The oregano leaves or bay leaves (used in cooking) contain about 1.3% essential oils. Major compounds in cinnamon are volatile oil [(*E*)-cinnamaldehyde]and several polyphenols mainly proanthocyanidins and catechins[5,6]. These components significantly impart antibacterial properties. Lopez *et al*[6]. and Rodr´ıguez-Lafuente *et al*[7]. reported the antimicrobial activity of cinnamon, oregano, and thyme essential oils against various Gram-negative/ Gram-positive bacteria, yeasts and molds.

Experimental

Fabric

For the purpose of application of antimicrobial compounds, plainwoven cotton and polyester/cotton

fabrics were used. The construction particulars of the fabrics are shown in Table 1.

Extraction of Active Compound

Antimicrobial compounds used for this study were extracted from oregano leaves and cinnamon bark pieces which are two important spices frequently used in food preparation. The respective plant parts were collected, cleaned and dried at 40ºC in a drier. These dried plant materials were powdered into fine particles with the help of a domestic grinder. The active compound (antimicrobial agent) was extracted using organic solvent (ethylene) using the soxhlet apparatus**.** The extract was filtered using Whatman filter paper IV. The solvent was then distilled under reduced pressure in a rotary evaporator until it becomes completely dry.

Application

Natural extracts at 10% (owf) concentration were applied on pre-washed cotton and polyester/cotton fabric samples using the conventional pad-dry-cure process. Glutaraldehyde as cross-linking agent (8% owf) and sodium hypophosphite (2% owf) as a catalyst were used. Fabric samples were padded through a laboratory padding mangle with two dips and two nips to give a wet pick up of 85 ± 5% (owf). Later the samples were dried at 85^{O}C for 5 min and then cured for 2 min at 120^{O}C.

Evaluation of Antimicrobial Activity

Modified colony counting method (AATCC test method 147-1998) was used to determine the antibacterial activity of untreated and treated fabric samples against *Staphylococcus aureus*and *Escherichia coli* and test results were expressed in terms of % reduction of bacterial growth.

Wash Durability Test

The finished fabric samples were subjected to multiple washes using a launder-o-meter as per ISO 6330-1984E. Then antimicrobial activity for washed fabric samples wasdetermined and activity retention % was calculated.

Fabric Properties

Bending length of fabric samples was measured by the cantilever principle, as per test method BS 3356. Shirley crease recovery tester was used to measure crease recovery angle of treated and control fabrics as per test method BS EN 22 313.Tensile strength was evaluated by using Hounsfield Universal Tester, UK (CRE) as per test method BS 2576.

Table 1 — Construction particulars of test fabrics

Fabrics	Ends/cm × picks/cm	Yarn count tex	Fabric weight, GSM
Cotton fabric	40 × 36	12 × 13	113
Polyester/ cotton fabric (67/33)	40 × 33	14 × 12	115

Results and Discussion

Evaluation of Antimicrobial Activity by Suspension Test (Quantitative)

Figure 1 shows the antimicrobial plates laden with *E. coli* for untreated and treated cotton fabric with oregano and cinnamon. Substantial reduction in number of bacterial colonies for treated fabrics is observed.

From Table 2, it is observed that the antimicrobial efficiency of cotton fabrics treated with oregano and cinnamon extract is ranging from 94% to 97% against test bacteria. In general, the activity against Gram-positive bacteria is higher than that of Gram-negative bacteria. Gupta and Laha[8] have also reported that the Gram-positive bacteria are more sensitive to the bactericidal effect of antibacterial agents than Gram-negative bacteria. It is noted that the washed oregano treated cotton fabric retaines its antimicrobial properties up to a maximum of 95% against *E. coli*, whereas cinnamon treated fabricretains 73% of its

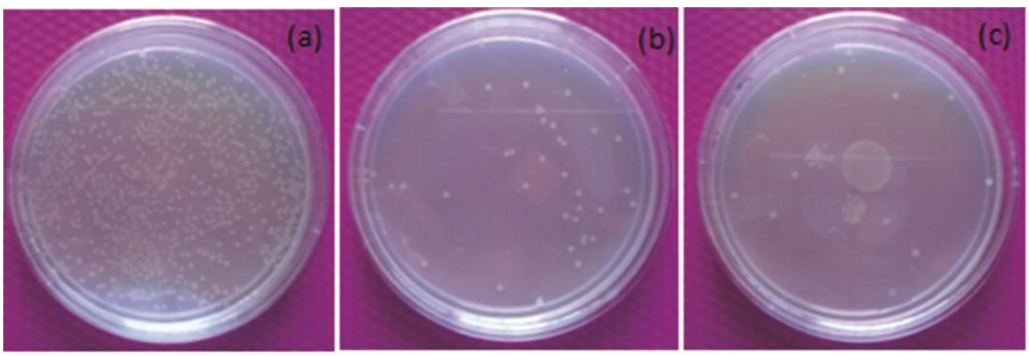

Fig. 1 — Reduction in bacterial colonies of E. coli (a) untreated cotton, (b) cotton treated with oregano and (c) cotton treated with cinnamon

Table 2 — Antimicrobial properties of cotton fabric treated with oregano and cinnamon

Antimicrobial agent	*S. aureus*		*E.coli*	
	Number of colonies at 10^{-6} dilution	% inhibition	Number of colonies at 10^{-6} dilution	% inhibition
Untreated	200	–	165	–
Oregano				
Before wash	7	97	18	89
After wash	55	73	35	85
Cinnamon				
Before wash	12	94	20	88
After wash	60	70	44	73

Table 3 — Antimicrobial activity of polyester/cotton fabric treated with oregano and cinnamon

Antimicrobial agent	*S. aureus*		*E.coli*	
	Number of colonies at 10^{-6} dilution	% inhibition	Number of colonies at 10^{-6} dilution	% inhibition
Untreated	118	–	135	–
Oregano				
Before wash	15	87	24	82
After wash	60	49	85	37
Cinnamon				
Before wash	8	93	16	88
After wash	46	61	56	59

activity. The reason may be attributed to ineffective mordanting. Even though a cross-linking agent could be able to fix the antimicrobial compound with the fibre, there is a small reduction in antibacterial activity which may be due to the removal of some unfixed active compounds during washing. However, all the treated fabrics retain a considerable amount of antibacterial activity even after repeated washes.

From Table 3, it is observed that the antimicrobial efficiency of the treated cotton fabric against *S. aureus* and *E. coli* is high as compared to polyester/cotton blended fabrics. This indicates that the uptake % of the antimicrobial compound of cotton fabric for a given concentration of 10% is found to be higher than that of polyester/cotton fabric. It is observed that the loss of antimicrobial efficiency due to washing for treated cotton fabric is less than that of polyester/cotton blended fabric. This is in line with observations of Joshi *et al.*[9], the active ingredients may be attached to cellulose by physical bonding and the cross-linking agent may act as a bridging material for chemical bond formation. The cellulose part in the blend fabrics is actively involved in bond formation with the active ingredients of the natural extract.

Table 4 — Effect of finish on properties of cotton fabric treated with oregano and cinnamon

Particulars	Cotton		
	Untreated	Treated	
		Oregano	Cinnamon
Bending length, cm			
Warp	1.96	1.93	1.88
Weft	1.56	1.78	1.84
Avg.	**1.75**	**1.85**	**1.86**
Creas ere covery angle, deg			
Warp	69	72	75
Weft	71	73	**76**
Total	**140**	**145**	**151**
Breaking strength,kg			
Warp	44.2	35.3	40
Weft	32.2	28	30
Avg.	**38.2**	**32**	**35**
Elongation, %			
Warp	14.5	10	12
Weft	26	25	23
Avg.	**20.3**	**17.5**	**17.5**

Table 5 — Effect of finish on properties of polyester/cotton fabric treated with oregano and cinnamon

Particulars	Polyester/cotton		
	Untreated	Treated	
		Oregano	Cinnamon
Bending length, cm			
Warp	2.08	2.1	2.2
Weft	1.72	1.8	1.9
Avg.	**1.89**	**1.94**	**2.04**
Crease recovery angle, deg			
Warp	90	93	91
Weft	85	93	91
Total	**175**	**186**	**182**
Breaking strength, kg			
Warp	70.3	70	68
Weft	51.5	49	50
Avg.	**60.9**	**59.5**	**59**
Elongation, %			
Warp	16.3	11	12
Weft	24.4	23	22
Avg.	**20.4**	**17**	**17**

Fabric Properties

Bending length test results (Tables 4 and 5) indicate that the cotton and polyester/cotton fabrics become slightly stiffer after finishing with the extracts**.** It is noted that the fabrics treated with antimicrobial agents along with cross-linking agents offer an improved crease recovery angle as compared to the corresponding untreated fabrics**.** However, the increase in the crease recovery angle of treated polyester/cotton blended fabric ranging from 182^{o} to 186^{o} is found to be high as compared to 100% cotton fabric sample having crease recovery angle ranging from 140^{o} to 151^{o}. This is due to the excellent crease recovery properties of the polyester component present in the blended fabrics.

Tables 4 and 5 show that the breaking strength retention of cotton fabric after treatment is 84 – 92 %, whereas blended fabric retains breaking strength up to 98%. It means, blended fabric sample offers slightly more breaking strength retention (6.5%) as compared to cotton fabric. The loss of strength could be attributed to molecular degradation of the cotton fabrics together with rigidity conferred on the latter by factors associated with cross-linking[10]. This suggests that the tensile strength of polyester/cotton fabric is not seriously affected by the treatment. The retention of elongation of fabrics is 14 %, which is more or less the same for both cotton and polyester/cotton fabrics before and after treatment.

In the present study, antimicrobial agents extracted from oregano and cinnamon (essential oils) have been utilized for the finishing of fabrics to impart antimicrobial properties. The study shows that treated fabrics register above 90% antimicrobial activity against *S. aureus* and *E. coli* bacterial strains. Hence, antimicrobial agents derived from oregano and cinnamon have the potential to be used in the antimicrobial finishing of textiles. The agents impart excellent antimicrobial properties to both cotton and polyester/cotton blended fabrics. After 10 washes, the efficacy of antimicrobial activity is reduced by 10-20%. The eco-friendly and nontoxic properties of these herbal extracts are promising candidates for medical and health care textile applications. The treated fabrics exhibit increased crease recovery properties, but their flexibility, tensile strength and elongation properties are slightly affected.

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