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Antimicrobial, UV-repellent and comfort properties of various herbal treated fabrics

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Aloe vera, *Adhathoda vasica*, *Agele marmelos, Calendula officinalis*, and *Solanum trilobatum* herbal extracts have been used to treat cotton fabric using the pad-dry cure technique. Three distinct herbal treatments have been used on the fabrics, each of which has its unique therapeutic properties which is more suited to older individuals. The study focuses on developing herbal finished fabrics for old age people to prevent them from microbes and UV rays, and to increase the comfort property. Air permeability, wickability, absorbency, thermal conductivity, tensile strength anti-microbial and UV repellence properties have been studied. It is found that the finished fabrics show moderately good UV repellent protection and has antimicrobial creativity.

Keywords: Antimicrobial, Comfort properties, Cotton, Functional property, Herbal treatment, Thermal comfort, UV repellent

1 Introduction

People who are older often have several physical and emotional issues. In old age, skin goes through a lot of changes; easily damaged by the sun. UV light causes the skin's elastic tissue to break down, causing sagging, wrinkles, and even skin cancer in older people[2]. In the human civilization, plants are used not only for the basic needs of life such as food, fibre, fuel, cloths and shelter but also act as finishing agents for fabrics where they enhance the skin's capacity to block and reject toxic substances and release their therapeutic properties into the body especially for old aged people as their skins are more sensitive. Microbes can easily affect those using wheelchairs and those who spend a lot of time on bed[3]. The spread of germs is also caused by the passage of moisture (sweat) from the skin[4]. Antimicrobial textiles have lots of applications, especially in the medical field which is used to control the infection in that specified area[5]. There is high demand of eco-friendly antimicrobial textiles that successfully reduce the negative impacts[6]. The primary prerequisite for life on earth is sunlight. Small exposure of ultraviolet (UV) radiation and the shortwave portion of sunlight are good for humans, but long-time exposure can cause skin cancer, photokeratitis, cataracts, and erythema (sunburn), especially in the elderly[7]. UV radiation varies daily, seasonally, and geographically in intensity and dispersion. Exposure to sunlight directly results in erythema (sunburn). The redness linked with sunburn is caused by the body, sending additional blood to the injured skin in an effort to heal the damage. Older people's skin is more vulnerable to UV radiation because it is more delicate[8].

A recent market study has unequivocally shown that consumers who buy clothing around the world want useful products. Some of the best examples of functionality in products include wrinkle resistance, dirt release, water repellence, flame retardancy, and microbial invasion resistance. Among them antimicrobial fabric qualities are recognised as a crucial and inevitable requirement for clothing that comes into touch with the human body directly[9].

Clothings encounter microorganisms (mould, mildew, fungus, yeast, bacteria, and viruses) every day. Microorganisms can be of both good and bad varieties. Numerous issues with textiles are caused by microbes, their body parts, metabolic products, and

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reproductive parts. Human irritants, sensitizers, toxic response agents, disease-causing agents and plainly uncomfortable agents exist. Inhibiting or eradicating the growth of microorganisms, particularly pathogenic bacteria, is what is meant by an antimicrobial finish. A wide range of textile items treated with antimicrobial characteristics are needed and expected as customers become more conscious of the importance of living hygienically. Microorganisms can proliferate because of the textile fibres' special qualities. Additionally, the chemical reactions and substrate structure may encourage the growth of microorganisms.

The skin can be stimulated in a variety of ways by aloe vera. It removes excess oil build-up and acne, offers natural moisture, works as an exfoliant and anti-pollution agent, and guards against skin infections. Aloe vera, *Adhathoda vasica*, *Aegle marmelos*, *Calendula officinalis* and *Solanum trilobatum* are examples of medicinal plants with demonstrated healing ability[10].

The fabric which repels away the ultraviolet radiations and protect human from skin diseases is UV repellent finish. For life to exist on earth, sunlight is a must. Solar protection factor (SPF) or UV protection factor of a fabric refer to its capacity to shield its wearer from ultraviolet rays (UPF)[11].

In this study, Aloe vera, *Adhathoda vasica*, *Aegle marmeols*, *Calendula officinalis* and *solanum trilobatum* extracts have been used to treat cotton fabric for unique therapeutic properties of treated fabric.

2 Materials and Methods

Plain 100% cotton woven fabric of GSM 84 g/m^2 and thickness 0.30 mm was selected. EPI and PPI were 52 and 48 respectively. The cotton grey fabric was bio scoured using pectinase 7 g/L, *p*H 4, temperature 40^{o}C, time 45 min and liquor ratio 50:1, and washed with soap solution followed by normal water wash to remove the natural impurities and then bleached with hydrogen peroxide.

2.1 Extraction Procedure

The herbs selected were aloe vera, *Adhathoda vasica*, *Aegle marmelos*, *Calendula officinalis*, and *Solanum trilobatum*. The herbs were collected in and around Tirupur, Tamil Nādu, India. The extraction process was carried out using the plant tissue homogenization method. The collected herbs were dried with morning sunlight for one week to eliminate the moisture in herbs and then grinded into fine shape. In a conical flask, 10g of powder was added to 100mL methanol then added 100mL water and shaken vigorously. The mixture was left as such for 24 h and then heated at 70 ˚C with gentle continual stirring to remove the methanol. Finally using ordinary filter fabric, the solution was filtered. The same procedure was repeated for all the herbs and finally stock solutions were prepared respectively. Except for aloe vera, all the other herbs produced a colour similar to dark green while aloe vera produced a pale green colour.

2.2 Method of Application

The pad-dry-cure procedure was used to apply the extracted herbal solutions to the cotton fabrics. The cotton fabric was padded with extract solution and passed to the squeezing roller in universal padding mangle with 110 % expression at 28 ^{o}C. The fabric was treated with three different herbal concentrations as shown in Table 1 and marked as Treated A, Treated B and Treated C respectively.

2.3 Physical Property Assessment

The following physical properties were evaluated using the following conventional procedures on samples of controlled and treated cloth made using three different recipes. For each test, ten samples were examined, and the discussion utilised the average result. The standard methods used are ASTM D 737-96 for air permeability test, ASTM E96 for water vapour permeability test, AATCC 197 for Vertical wicking test, ASTM C177 for thermal conductivity, ASTM D5035-11 for tensile strength, ASTM D6420-18 for GC-MS analysis, ATCC 6538 & ATCC 4352 for antimicrobial testand AATCC 183:2010 for UV protection test.

3 Results and Discussion

3.1 Air Permeability test

Figure 1 (a) shows that the air permeability of the untreated fabric is better as compared to that of the herbal finished fabrics. This is mainly due to the reason that the applied herbal extracts slightly block the pores in the fabric which affects the passage of air to pass through the fabric pores[12,13].

Table 1 — Particulars of three different recipes of each herb

Particulars	Treated A	Treated B	Treated C
Material weight, g	20	20	20
MLR	1:10	1:10	1:10
Stock solutions, mL	10	15	20
Combined herbal solution, mL	50	75	100
Water, mL	150	125	100
Total liquor, mL	200	200	200

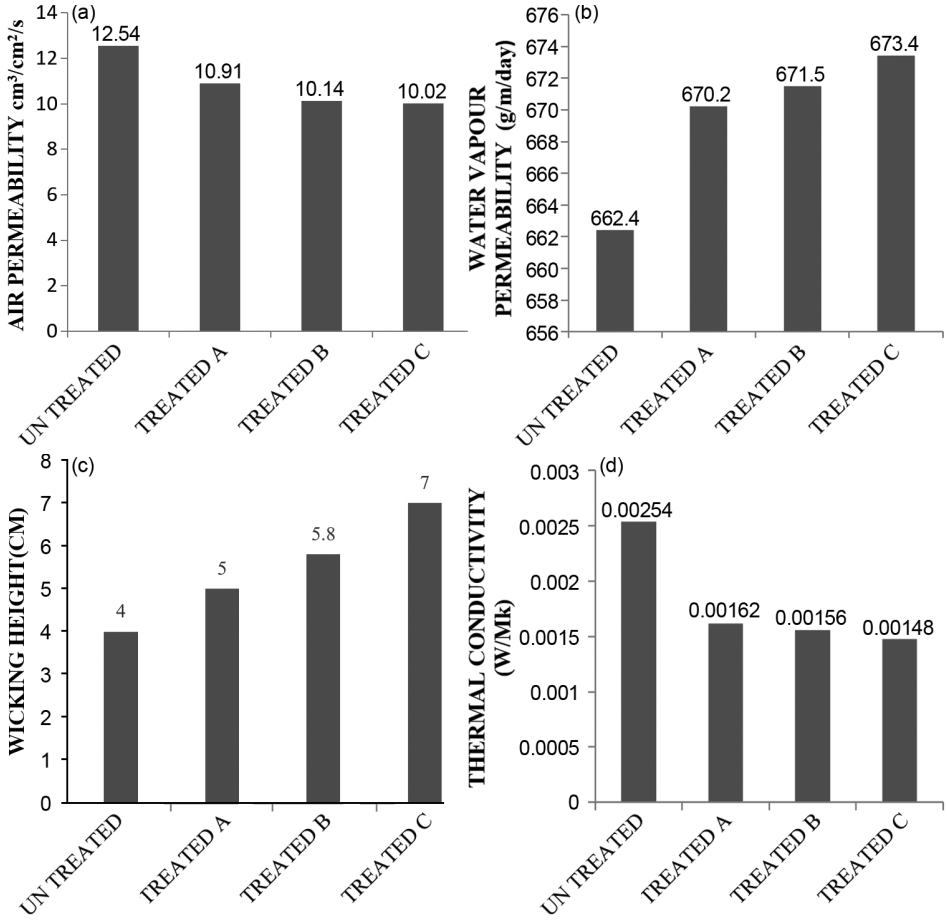


Fig. 1 — (a) Air permeability, (b) water vapour permeability, (c) wicking test and (d) thermal conductivity tests results

3.2 Water Vapour Permeability Test

Figure 1 (b) shows that all the three samples have good moisture vapour permeability even after being finished with herbal extracts as compared to untreated sample. This enhancement in water vapour permeability may be attributable to the chemical groups found in herbs, which boost their capacity for water absorption and let the water to move more quickly through fabric pores to the atmosphere. This finding helps in moving the moisture stored up on the skin since perspiration moves from the skin to the fabric and then to the atmosphere, slightly lowering the heat build-up[14].

3.3 Vertical Wicking Test

Figure 1 (c) shows that the wickability of the untreated fabric is good, though its wickability is lesser than that of treated fabrics. The water absorbency is found to be good in the case of the herbal finish treated Sample C. The presence of phyto components of aloe molecules in the herbal extraction absorbs more moisture making it highly wick[15].

3.4 Thermal Conductivity

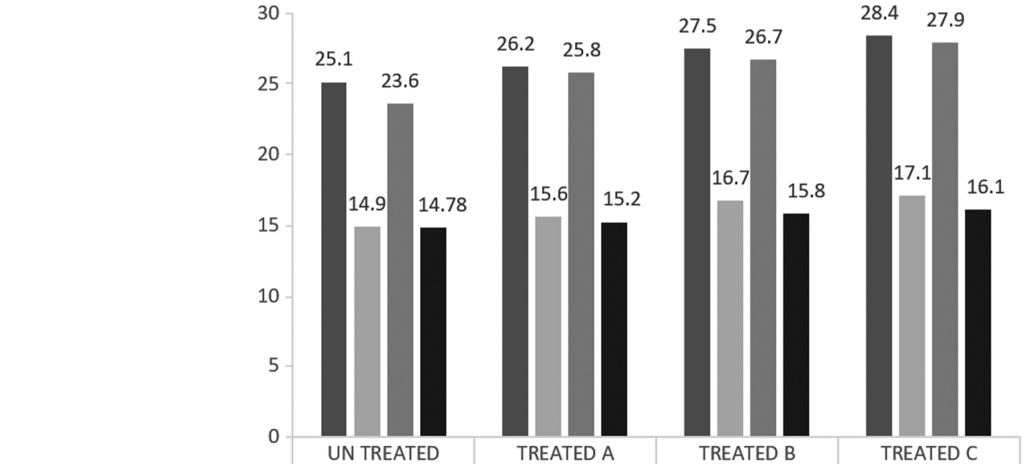
Figure 1 (d) shows that untreated samples only possess a better thermal conduction on comparison with the treated one. This is mainly because the conduction takes place well at a dry state and the treated fabrics show good moisture absorbency and wicking property, which result in lower thermal conduction due to increase in absorbing moisture from the environment. Also, the fibre being cotton, there is a high chance for the thermal conduction to get reduced[16].

3.5 Tensile Strength

The treated samples show a very good tensile strength. The imparted herbal finishes support the improvement in strength of the fabric. This is primarily caused by the organic molecules of the extracts that are adsorbed in the fabric's voids and help the fabric to resist the tensile load (Fig. 2).

3.6 GCMS Study

From the gas chromatography mass spectrometry (GCMS) study, it is observed (Table 2) that the below-



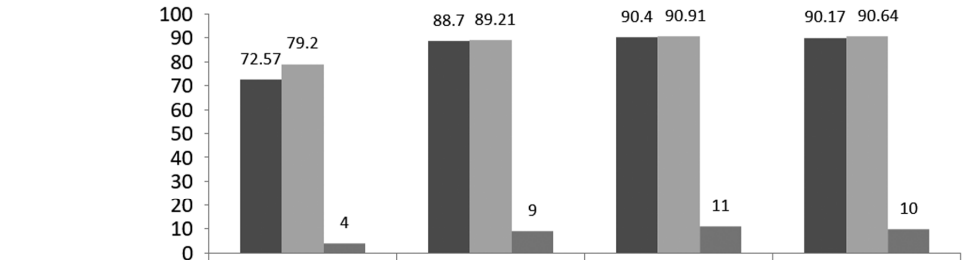
	UN TREATED	TREATED A	TREATED B	TREATED C
Warp way tensile strength,Kg	25.1	26.2	27.5	28.4
Warp way elongation, %	14.9	15.6	16.7	17.1
Weft way tensile strength,Kg	23.6	25.8	26.7	27.9
Weft way elongation, %	14.78	15.2	15.8	16.1

Fig. 2 — Tensile strength results

Table 2 — GCMS study of herbal extraction

Compound	Aloe vera	*Calendula officinalis*	*Agele marmelos*	*Adhathoda vasica*	*Solanum trilobatum*
1-Monolinoleoylglycerol trimethylsilyl ether	+	+		+	
1,2-Benzenedicarboxylic acid, diisooctyl ester	+	+			
9,12-Octadecadienoic acid (Z,Z)	+	+			
Tetradecanoic acid	+				
n-Hexadecanoic acid	+	+	+	+	+
1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	+				
1,2-Benzenedicarboxylic acid, mono(2-ethylhexyl) ester	+	+			
1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	+	+			+
9-Octadecenoic acid (Z)		+			
Squalene		+	+	+	
5-Hydroxymethylfurfural		+			
Neophytadiene			+		+
Vitamin E				+	+
9,12,15-Octadecatrienoic acid, methyl ester					+
á-Sitosterol			+		+
Stigmasterol			+		+
Phytol, acetate			+		+
3,7,11,15-Tetramethyl-2-hexadecen-1-ol			+		+
9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)			+	+	
2-Hexadecen-1-ol, 3,7,11,15-tetramethyl-, [R-[R*,R*-(E)]]				+	
1-Heptatriacotanol				+	

mentioned phyto components are present in the herbal extraction. The GCMS study confirms the presence of phyto components such as 1-monolinoleoylglycerol trimethylsilyl ether, 1,2-benzenedicarboxylic acid, diisooctyl ester, 1,2-benzenedicarboxylic acid, bis(2-ethylhexyl) ester, 1,2-benzenedicarboxylic acid, mono(2-ethylhexyl) ester, n-hexadecanoic acid, 9-octadecenoic acid (Z)-, squalene, neophytadiene, vitamin E, á-sitosterol, stigmasterol, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, 2-hexadecen-1-ol, 3,7,11,15-tetramethyl, [R-{R*,R*-(E)}], 1-heptatriacotanol in the herbal extract which supports the antimicrobial, UV protection property and further it can also act as an anti-cancer substance and anti-inflammatory component to some extent.



	UN TREATED	TREATED A	TREATED B	TREATED C
UV A BLOCKING %	72.57	88.7	90.4	90.17
UV B BLOCKING %	79.2	89.21	90.91	90.64
UPF RATING	4	9	11	10

Fig. 3 — UV repellency test results

Table 3 — Zone of bacteriostatic using cotton fabric

Finish	Zone of bacteriostatic, mm	
	S. aureus	*E. coli*
Untreated	0	0
Treated A	24	20
Treated B	29	28
Treated C	32	30

3.7 Antimicrobial Test

The agar diffusion test is a preliminary method to identify the diffusive antimicrobial finish. The ability of three treated samples and one untreated sample to stop the growth of *Escherichia coli* and *Staphylococcus aureus* has been tested. Agar diffusion test was used to assess the antibacterial activity of samples treated with herbs displayed in (Table 3). Agar was used by AATCC as a bacterial growth medium [temperature 37 °C, time frame 24 - 48 h, control sample dimensions 19 mm diameter (circular swatch)]. On grass culture plates, both treated and untreated samples are placed, and then incubated for 24 - 48 h at 37°C. After the incubation period, the zone of inhibition has been assessed using a zone scale. In this test, treated cotton's zone of inhibition against *S. aureus* is found higher than that against *E. coli*, while the zone of inhibition for untreated cotton is found to be nil.

3.8 UV Repellency Test

Figure 3 shows that the UPF rating of Treated B and Treated C fabrics is 11 and 10 respectively with moderately good protection category. Comparing the untreated fabric, the UV protection of treated fabric is found higher.

4 Conclusion

Thus the five finished fabrics offer moderately good UV repellent protection and also has antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, according to the results of several types of tests done on finished and unfinished fabrics. The herbal finished fabric can be used to create a variety of clothing items for older people because it has passed many tests and has the comfort, antibacterial, and UV repellency qualities that are essential for clothing for older people. These fabrics can, therefore, be utilised to assist both the environment and humans because they are both affordable and the leftovers from the fabrics do not harm the environment.

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