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Ultraviolet Radiation Protection of Human through Protection Coverings: Bamboo

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Abstract: **-- Ultraviolet radiation is the hazardous form of radiant energy emitted from sun. The sun emits a range of energy known as the electromagnetic spectrum. The various forms of energy or radiations are classified according to its wavelength. The shorter the wavelength, more energetic radiation and more hazardous to humans. Sunlight that reaches the earth is composed of 66% Infrared light, 32% Visible light and 2% Ultraviolet light. There are three categories of UV radiations UV-A (320-400 nm), UV-B (280-320 nm) and UV-C (200-280 nm). The increasing pollution day by day makes the situation more dangerous and causes severe destructive effects on ozonosphere, which causes more ultraviolet radiation reaching the earth surface.**

Exposure of humans and their skin to ultraviolet radiation of different wavelengths are very hazardous and harmful to humans. As exposure to these radiations causes various skin tissues damages, which leads to several problems visible on the surface of skin, such as early ageing of skin, roughening, wrinkles, blotches, sagging and regular exposure for long durations even leads to skin cancer. This research elaborates the in depth study of ultraviolet radiation and its effects and exposure to humans and specific to their skin. The study involves study of various protection methods specifically in terms of clothings or apperel or coverings. The study uses various natural, regenerated and synthetic fibres and materials tested for protection from this hazard of ultraviolet radiation. The study reveal that, bamboo fibre or material or coverings made from its combinations protects human skin from harmful and hazardous damages caused by UV radiation, because it naturally possesses anti-UV radiation characteristics In this study samples of various weaves like plain and twill fabric were produced from bamboo, cotton, polyester and bamboo:cotton(50:50) blended yarns. The result shows that bamboo fabric has shown higher UV protection than cotton fabric of similar specification. It is also observed that twill weave exhibits higher UV protection than plain weave and useful for industrial manufacturing clothings, protective clothing and coverings.

Keywords: bamboo, coverings, plain, twill, ultraviolet, protection.

1. INTRODUCTION

Ultraviolet radiation is the one form of radiant energy emitted from sun. The sun emits a range of energy known as the electromagnetic spectrum. The various forms of energy or radiation are classified according to wavelength. Shorter the wavelength more the energetic radiation. Ultraviolet which is invisible, it occurs next to violet in the visible light spectrum. There are three categories of UV radiation are UV-A (320-400nm), UV-B (280-320) and UV-C (200-280).

The ultraviolet light is a small invisible portion of sunlight which is responsible for destructive actions of sunlight. The exposure to UV radiation causes harm to human health. This radiation is composed of three types: UV-A, UV-B and UV-C rays. Generally UV-C type of radiation is absorbed by the ozone layer, while UV-A and UV-B reaches to earth with wavelength ranging from 315-400 nm and 280-315 nm and causes serious health problems like Sunburn, skin aging, skin cracking, roughening and skin cancer. Textiles can provide effective protection against such damages [1].

The skin is the human body's largest organ which acts as a barrier against the environment. The three main layers of skin are epidermis (0.1-1.5mm), corium and subcutis, collectively called as the dermis. UV radiations can easily penetrate through the skin layers. UV-B radiations penetrate less deeply into the epidermis than UV-A radiation. Increased penetration of UV-B radiation is likely to have a profound impact on human health with potential risks of eye diseases, skin cancer and infectious diseases. UVR is also known to damage the cornea and lens of the eye [1].

The factors affecting UV radiation are cloud cover, sun's altitude, geographical position, ozone layer and environmental conditions. When any UV radiation falls on textile material it is partly reflected, absorbed and partly transmitted through the fibres and pores of a fabric. UV protection of garment is dependent on parameters viz structure, fabric weight, count, fabric density, thickness, porosity, cover factor and color shade etc [2].

Protection from sunlight includes use of protective garments and accessories. The minimum exposure to sunlight is the one way of sun protection. Protection from UV radiation can be obtained by using appropriate

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apparel and accessories such as hats, shoes, shade structures such as umbrellas, baby carrier covers etc.

The harmful effect of UV radiation can be prevented by wearing heavy weight garments. However the use of heavy weight fabrics is unacceptable, due to the resulting increase in skin temperature, which is both uncomfortable and a health hazard. Therefore there is growing demand in the market for textile apparel that offers comfort and protection from UV-A and UV-B radiation [3].

The undyed and untreated fabrics have less UV absorption and higher UV transmission to skin, thus such fabric gives less protection, whereas dyed fabrics have less UV transmission and it gives better protection than undyed fabrics [4].

A textile scientist plays an important role in ultraviolet protection. Textile material can be a very simple and convenient barrier against ultraviolet rays and can offer suitable or even excellent ultraviolet protection. Textile materials have UV blocking properties. These properties can be enhanced by dye, pigment, delustrant, UV absorber as well as by their construction. Fabric construction presents the simplest and cheapest solution to achieve better UV protection without additional finishing processes [5].

Every fabric doesn't provide sufficient UV protection. The UV protection of a fabric is evaluated in terms of ultraviolet protection factor (UPF). The UPF evaluates the reduction in the amount of UV radiation that passes through the fabric to the skin. For example, when a fabric has, a UPF of 20, it means only 1/20 th of UV radiation reaches the skin [2], [5], [6].

1.1 Classification of Different Skin on the basis of Sensitivity to UV Radiation

Table I Classification of Different Skin on the basis of Sensitivity to UV Radiation [1]

Classification of Different Skin by Sensitivity to UV Radiation					
Skin Type	**Description**	**Sunburn**	**Tanning**	**Skin's Intrinsic Protection Time**	**Textile Protection (UPF 20)**
I	Skin: extremely light, pale Hair: reddish Eyes: green, blue, very occasionally brown	burns, Painful	tans white after1-2 days, skin peels	min	minutes
II	Skin: slightly darker than type I Hair: blonde to brown Eyes: blue, green, grey	Generally burins, painful	Rarely tans, skin peels	10-20-min	200-400 minutes
III	Skin: light brown Hair: dark blonde, brown Eyes: grey brown	Occasionally burns	Tans well	20-30-min	400-600 minutes
IV	Skin: brown Hair: dark brown, black Eyes: dark	Rarely burns	Tans quickly and deeply	Approx. 45 min	Approx. 900 minutes
V	Skin: dark Hair: black Eyes: dark	Rarely burn	Tans quickly and deeply	Approx. 60 min	Approx. 1200-1800 minutes
VI	Skin: black Hair: black Eyes: black	Rarely burn	Tans quickly and deeply	Approx. 90 min	More than1800 minutes

Source: Swiss Textile TestingInstitute.2006, Jun. Enjoy the sun safely: Textile UV Protection. TEXTEXRetrieved February15, 2008 from http:// www.testex.com/bilder/pdf/UV_standard_801_broschure_e.pdf.

1.2 Standards for UV Protection of Fabrics

Table II Standards for UV Protection of Fabrics[1]

Organisations	Standard	Title
Standards Australia/New Zealand (AS/ZS)	AS/NZS 4399	Sun protective clothing evaluation and classification
The European Committee for Standardization	EN 13758-1 EN 13758-2	Classification and marking of UV protective apparel
British Standards Institution	BS7949	Children's clothing: requirement for protection against erthemally weighted solar UV radiation
American Society for Testing and	ASTM D 6603	A standard guide for labelling of UV Protective Textiles

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Materials		
Commission Internationale de l Eclairage	CIE TC 6-29	Proposed UV protective index for clothing
International Test Association for Applied UV Protection	UV Standard 801	UV standard 801

Source: Schindler, W. D., Hauser P. J. 2004. Chemical Finishes of Textiles. Woodhead Publishing Ltd. USA PP162.

1.3 Different UPF Ranges and Ratings

Table III Different UPF Protection Ranges & Ratings[1]

UPF Range	Protection Category	Effective UVR Transmission%	% UV Blocked	UPF Rating
15-24	Better Protection	6.7-4.2	93.3 - 95.8	15, 20
25-39	Very Good Protection	4.1-2.6	96.0-97.4	25,30,35
45-50, 50+	Excellent Protection	2.5	97.5-98.0	40,45,50, 50+

Source: Postle R.2008. Application of Energy Considerations to Ultravioet Protection of Textile Filters and Textile Screens for Industrial Safety. Retrieved February 15, 2008 from 140. 134. 132. 124: 8080 /dspace /bitstream /2377/3876/1/ce05atc902007000005.pdf.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1 Fibre Properties

Table IV Properties of Bamboo Fibre	
Strength (g/tex)	34.3
Elongation (%)	16.0
Short Fibre Index (12.7mm)	5.58
Uniformity Index (%)	92.7
UHML(mm)	38.745
ML (mm)	35.62
Moisture (%)	6.5
Micronaire	4.0

Table IV shows l properties of bamboo fibre. Strength (gm/tex), Elongation (%), Short fibre index, Uniformity index, Moisture (%) and Micronaire are 34.3, 16.0, 5.58, 92.7, 6.5 and 4.0 respectively.

2.1.2 Production of Bamboo, Cotton, Polyester and Bamboo: Cotton (50:50) Fabrics

In order to investigate effect of fibre material, weave, thickness, weight, pick density, cover factor, blend, warp crimp and weft crimp on UPF, following fabric samples were used. In this study, plain and twill fabric samples were produced from bamboo, cotton, polyester and bamboo:cotton (50:50), blended yarns. These fabric samples were produced on automatic sample weaving machine with 50 PPI.

Table V Specifications of Fabric

Table V Specifications of Fabric				
Material	Weave	PPI	EPI	Warp and Weft Count
Bamboo	Plain, Twill	50	75	20,24,30,40
Bamboo-Cotton(50:50)	Plain, Twill	50	75	20,24,30,40
Cotton	Plain	50	75	30
Polyester	Plain	50	75	30

2.2 Testing Methods

2.2.1 Fibre Properties

Fibre properties such as strength, elongation, micronaire and uniformity index and moisture % etc. of bamboo are measured on Uster HVI SW 3.1.1.0 version.

2.2.2 Yarn Properties

Yarn properties such as strength and elongation are measured on Uster Tensorapid Tester (3 V 6.1) with gauge length- 20 inches, velocity of jaw 2000 mm / min, whereas unevenness, imperfection and hairiness were measured on IQ Qualicentre (version A 3.0.2) with 400 meter test length.

2.2.3 Fabric Properties

In order to obtain the results of bamboo fabric samples used in experimental work, testing of various required

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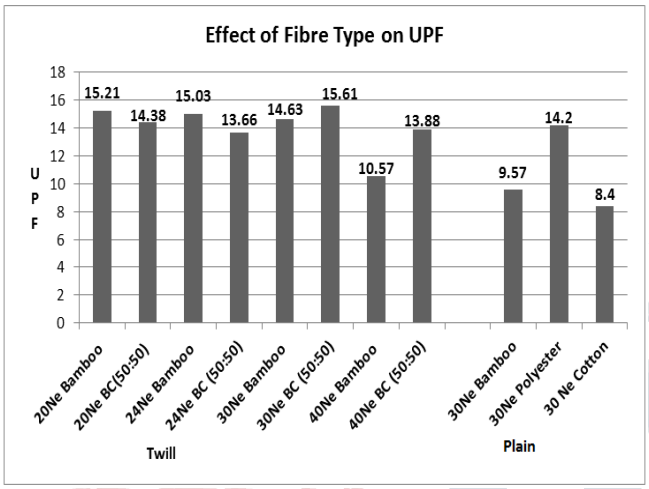
properties was carried out. This includes ultraviolet protection property (AATCC 183-2004), tensile strength, elongation, thickness, air permeability, cover factor, crimp and fabric weight.

3.0 RESULTS AND DISCUSSION

3.1 UV Protection of Woven Fabrics

3.1.1 Effect of Fibre Type on UPF



Graph-3.1 Effect of Fibre Type on UPF

Graph-3.1 shows results of ultraviolet protection factor (UPF). The UPF 30^{S}Ne bamboo, 30^{S}Ne polyester and 30^{S}Ne cotton fabric of 50 PPI is 9.57, 14.2 and 8.4 respectively. The bamboo fabric has shown 13.92% significantly higher UPF than cotton fabric of similar specifications. And the polyester fabric has also shown 69.04 % significantly higher UPF than cotton fabric of similar specifications. ANOVA: Results are statistically significant p-value 0.014.

This result is attributed to bamboo and polyester fibre, bamboo fibre has micro holes and micro gaps in its structure, due to this it absorbs more UV radiation and transmits less radiation to the skin. Whereas in case of cotton fibre, there are no micro holes and micro gaps in the structure, due to this it absorbs less UV radiation and transmits more UV radiation to the skin. Thus bamboo fabric shows higher protection than cotton fabric of similar specification.

The polyester fibre absorbs higher UV radiation than cotton and bamboo fibres, because polyester fibre is made of aromatic compounds, due to this it has ability to absorb higher UV radiation than cotton and bamboo fibres

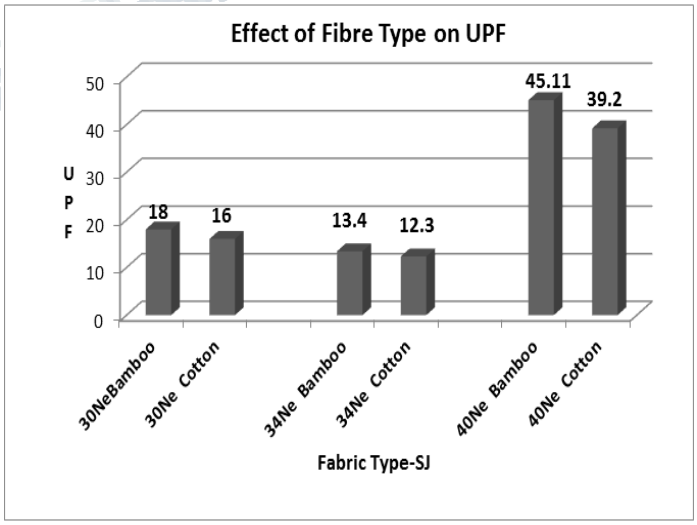
The UPF of 20^{S}Ne bamboo fabric and 20SNe bamboo: cotton(50:50) fabric of 50 PPI is 15.21 and 14.38 respectively. The 20^{S}Ne bamboo fabric has shown 5.77 % significantly higher UPF than 20SNe bamboo:cotton(50:50) fabric of similar specification.

The UPF of 24^{S}Ne bamboo fabric and 24SNe bamboo:cotton (50:50) fabric is 15.03 and 13.66 respectively. The 24^{S}Ne bamboo fabric has shown 10.02% higher UPF than 24^{S}Ne bamboo: cotton(50:50) fabric of similar specification.

Whereas in case of 30SNe fabrics, the UPF of bamboo fabric and bamboo:cotton (50:50) fabric is 14.63 and 15.61 respectively. It is observed that the UPF bamboo fabric is less than bamboo:cotton(50:50) fabric of similar specification. A reversed trend is found as compared 20SNe and 24SNe fabrics.

3.2 UV Protection of Knitted Fabrics

3.2.1 Effect of Fibre Type on UPF



Graph -3.2 Effect of Fibre Type on UPF

As shown in graph-3.2. The ultraviolet protection factor (UPF) of 30^{S}Ne Bamboo and 30^{S}Ne Cotton is 18 and 16

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respectively. The bamboo fabric has shown 12.5% higher UPF than cotton fabric of similar specifications. ANOVA: Results are statistically significant. The UPF of knitted fabric samples are statistically significant p-value 0.0178919

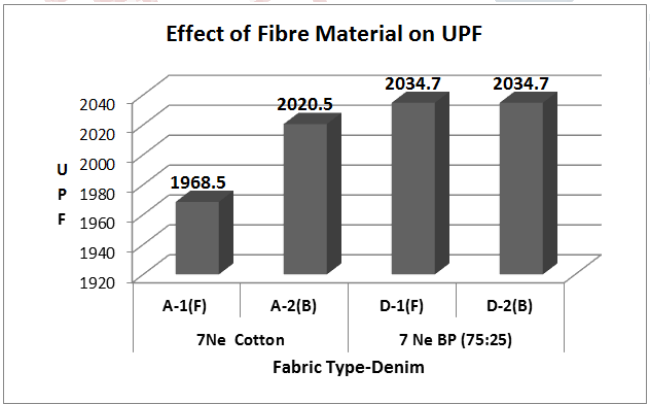
The ultraviolet protection factor (UPF) of 34^{S}NeCotton and 34^{S}Ne Bamboo is 12.3 and 13.4 respectively. From graph-3.2, it is found that the bamboo fabric has shown 8.94% higher UV protection factor than the cotton fabric of similar specification.

In case of 40SNe Bamboo and 40SNe Cotton the ultraviolet protection factor is 45.11 and 39.2 respectively. Bamboo fabric has shown 14.78% higher UV protection factor than cotton fabric of similar specification.

This result is attributed to the fact that, bamboo fibre has micro holes and micro gaps in its structure, due to this it absorbs more UV radiation and transmits less radiation to the skin. Whereas in case of cotton fibre, there are no micro holes and micro gaps in the structure, due to this it absorbs less UV radiation and transmits more UV radiation to the skin. Thus bamboo fabric shows higher UV protection than cotton fabric of similar specification.

3.3 UV Protection of Denim Fabrics

3.3.1 Effect of Fibre Type on UPF



Graph-3.3

As shown in graph-3.3. In case of fabric face side, UPF of 7^{S}Ne cotton fabric and 7^{S}Ne BP (75:25) is 1968.5, 2034.7 respectively. UPF of BP(75:25) fabric is 3.36 % higher than cotton fabric. In case of fabric backside, UPF of 7^{S}Ne cotton fabric and 7^{S}Ne BP(75:25) is 2020.5, 2034.7 respectively. UPF of BP(75:25) fabric is 0.7 % higher than cotton fabric. ANOVA: Results are statistically significant p-value 2.62E-33

It is observed that, bamboo:polyester fabric has shown higher values of UPF than cotton fabric. This is attributed to bamboo and polyester fibre, bamboo fibre has micro holes and micro gaps in its structure, due to this it absorbs more UV radiation and transmits less radiation to the skin. Whereas in case of cotton fibre, there are no micro holes and micro gaps in the structure, due to this it absorbs less UV radiation and transmits more UV radiation to the skin. Hence bamboo fabric shows higher protection than cotton fabric of similar specification. The polyester fibre absorbs higher UV radiation than cotton, because polyester fibre is made of aromatic compounds, due to this it has ability to absorb higher UV radiation than cotton fibre.

CONCLUSIONS

I) UV Protection of Woven Fabrics

i) Effect of Fibre Type on Ultraviolet Protection Factor (UPF)

•The ultraviolet protection factor of 30^{S}Ne bamboo fabric is 13.92% significantly higher than 30^{S}Ne cotton fabric of similar specifications. Thus bamboo fabric has shown higher ultraviolet protection factor than cotton fabric. Results are statistically significant.

•The ultraviolet protection factor of 30^{S}Ne polyester fabric is 69.04% significantly higher than 30^{S}Ne cotton fabric of similar specifications. Thus polyester fabric has shown higher ultraviolet protection factor than cotton fabric, but polyester fabric is not comfortable to wear. Results are statistically significant.

II) UV Protection of Knitted Fabrics

i). Effect of Fibre Type on Ultraviolet Protection Factor (UPF)

•It is seen that, the 30^{S}Ne bamboo fabric (Single Jersey) has shown 12.5% higher UV protection factor than 30^{S}Ne cotton of similar specifications. Results are statistically significant.

•It is observed that, the 34^{S}Ne bamboo fabric (Single Jersey) has shown 8.94% higher UV protection factor

than 34SNe cotton fabric of similar specification. Results are statistically significant.
•It is found that, the 40^{S}Ne bamboo fabric (Single Jersey) has shown 14.78% higher UV protection factor than 40SNe cotton fabric of similar specification. Results are statistically significant.
•Thus bamboo fabric exhibits better UV protection than cotton fabric of similar specification.

III) UV Protection of Denim Fabrics

•The ultraviolet protection factor of bamboo:polyester (75:25) fabric is 3.36 % higher than cotton fabric of similar specification.

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