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UV Protection Offered by Textile Fabrics

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It is common knowledge nowadays that prolonged exposure to ultraviolet rays (UVR) can be harmful for human health by inducing skin diseases such as acceleration of skin aging, photodermatosis and skin cancer, as well as the acute and chronic effects on eyes such as keratitis and cataracts. Therefore, the use of sunscreens and UV protective clothing has gained popularity. The effectiveness of textile materials to protect from UVR is determined by fabric composition (fibre type), construction (open porosity, weight and thickness), and finishing treatments (dyes, chemical agents, UV stabilizers). It is generally accepted that cellulose textile fabrics (cotton, viscose, flax) have low UV absorption capacity. On the other hand, cellulose-based textile materials are considered to be comfortable to wear (in the summer months especially) because of their excellent hygienic properties. Generally, dark colours provide better UV protection due to increased UV absorption. However, light pastel shades are preferable for using in warm weather. Therefore, the objective of this work is to develop cellulose-based textile fabrics with effective UV protection and keeping satisfied their comfort properties.

EXPERIMENTAL

Plain knitted fabrics were produced from the two-assembled hemp and cotton yarns in the way to obtain the pure hemp knit (2Cs) and three variants of 50% hemp/50% cotton knitted fabrics (CsCo1, CsCo2, CsCo3). These knitted fabrics were produced on a circular knitting machine under the same knitting conditions in order to obtain, as much as possible, identical structure.

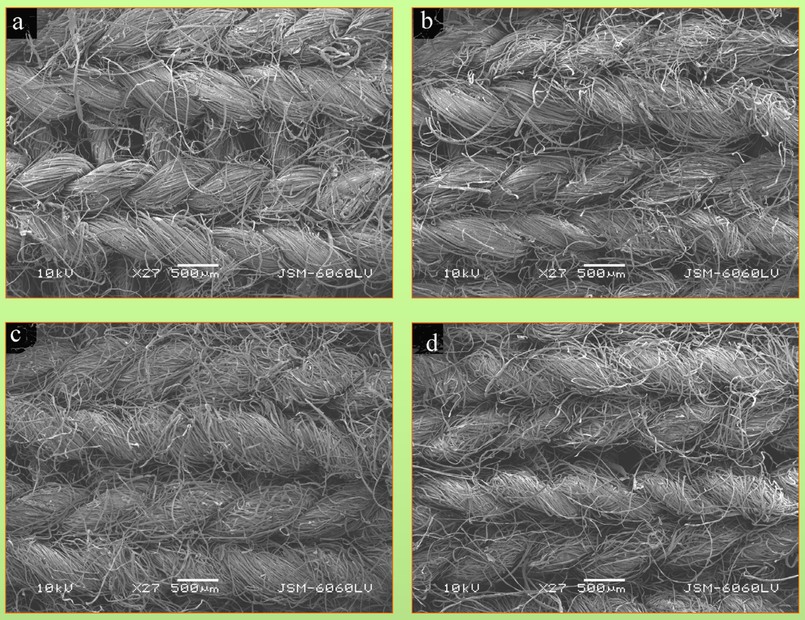
Construction characteristics of the hemp based knitted fabrics

Parameter, unit		2Cs	CsCo1	CsCo2	CsCo3
Stitch density	Course (cm^{-1})	13.7	13.0	12.0	12.5
	Wale (cm^{-1})	5.5	5.5	6.0	6.0
	Surface (cm^{-1})	75.4	71.5	72.0	75.0
Stitch area (mm^2)		1.33	1.40	1.39	1.34
Loop length (mm)		5.0	5.3	5.5	5.5
Thickness (mm)		0.916	1.047	1.068	1.069
Surface density (g/m^2)		360.4	366.6	379.8	399.5

UVR transmission were measured according to standard SIST EN 13758-1:2001 on the apparatus Lambda 800 UV/VIS Spectrophotometer PELA-1000 (Perkin Elmer). Ultraviolet Protection Factor (UPF), defined as the ratio of the average effective UV irradiance calculated for unprotected skin to the average UV irradiance calculated for skin protected by the test fabric, is calculated using the following equation:

$$UPF = \frac{\sum_{\lambda=290}^{\lambda=400} E(\lambda)\cdot\varepsilon(\lambda)\cdot\Delta\lambda}{\sum_{\lambda=290}^{\lambda=400} E(\lambda)\cdot T(\lambda)\cdot\varepsilon(\lambda)\cdot\Delta\lambda}$$

E(λ) – solar spectral irradiance ($Wm^{-2}nm^{-1}$),
ε(λ) – relative erythema effectiveness,
Δ(λ) – wavelength interval of measurements (nm)
T(λ) – spectral transmittance at wavelength λ

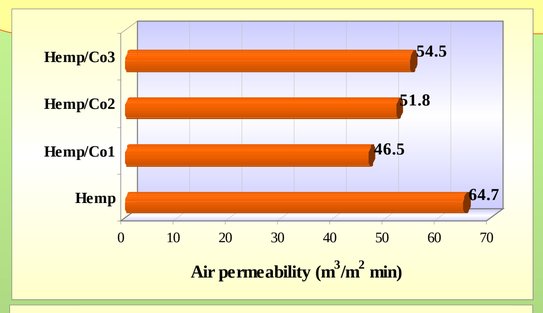


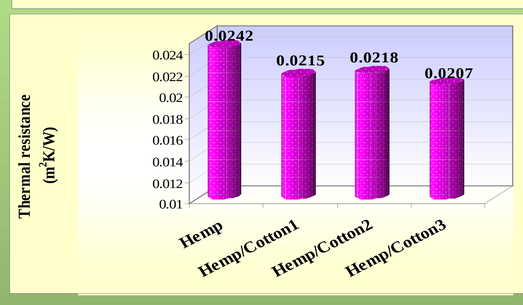
SEM microphotographs: Hemp (a); Hemp/Cotton1 (b); Hemp/Cotton2 (c); Hemp/Cotton3 (d)

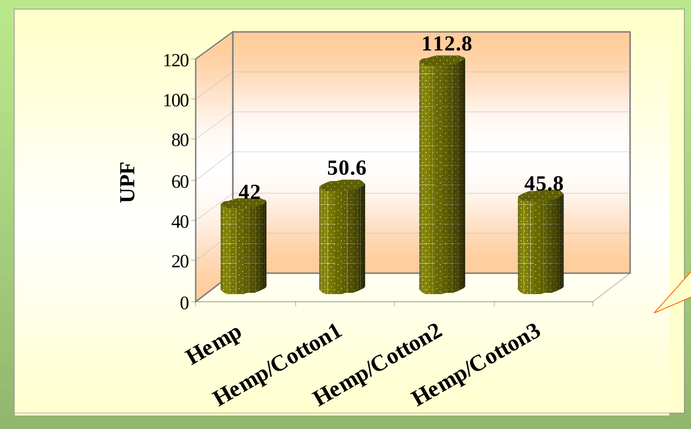
Geometry parameters of the hemp based knitted fabrics

Parameter, unit	2Cs	CsCo1	CsCo2	CsCo3
Bulk density, (g/cm^3)	0.398	0.353	0.356	0.377
Porosity, (%)	74.0	76.5	76.2	74.9
Open porosity, (%)	68.4	60.7	63.7	66.8
Surface stitch modulus	0.85	0.71	0.72	0.74
Volume stitch modulus	1.60	1.12	1.30	1.51

When UVR get to the fabric, it can be reflected, absorbed by fibre and transmitted through the fabric pores. Some of the incident radiation can be scattered by the fibres within the fabric, and further be absorbed by other fibres or transmitted via gaps between the fibres and yarn. According to the previous research evidence, the amount of UVR absorbed by the fabric is strongly influenced by the physico-chemical nature of fibre which is the key determinant of its ability to absorb UVR. Other components of the UVR distribution are determined by structural characteristics of the fabric (woven or knitted), which in turn is influenced by its geometry and yarn properties. Open porosity of textile material is a governing factor for its transport properties such as air permeability, heat transfer properties and UVR transmission. The higher the open porosity the higher the air permeability and UVR transmission through the fabric.







UPF 40+

Differences in UV protection properties (UPF values) of the knitted fabrics were indicated. Due to increased bending stiffness of the hemp yarn which resulted in a decrease of knitting barrier and an increase of wale spacing, the pure hemp knitted fabric was characterized by the lowest UPF. The cotton 2 yarn spacing, as well as its hairy surface, when was assembled with hemp yarn, contributed to the closing of the hemp/cotton2 knitted fabrics, thus lowering of UV transmission through them, i.e. improving the UV protection capability.

CONCLUSION

The results obtained indicate that the hemp and hemp based knitted fabrics are characterized by high UV protection ability (UPF range above 40) placing them in the "excellent UV protection category". Some limitations of the hemp fibre and yarn concerned with the lower elasticity and coarseness, which determine the open porosity of a knitted fabric through the influence on the knitting barrier, could be overcome by assembling with softer and hairy yarns. In conclusion, by designing the structure of yarn and fabric, as well as the fabric composition, it is possible to obtain hemp based knitted fabrics with the optimal UV protection properties and other wear comfort parameters of fabric.