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WAYS TO IMPROVE PROTECTION AGAINST UV RADIATION FOR CLOTHING PRODUCTS

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Abstract: *Worldwide, recent years are characterized by an increasingly acute manifestation of the ecological phenomenon, seeking solutions for obtaining products that are based on natural components, as well as the safe use of products. In this respect, in the textile industry, the concept of eco-fashion has developed: manufacturers and designers increasingly using eco-friendly materials and technologies. Ecofashion aims at protecting user's health, maintaining and securing the integrity of the environment, as well as improvement working conditions for service staff in the textile industry.*
Taking into consideration the natural changes that occurred in these last years (reduction of the ozone layer, solar flares, global warming), it was observed that solar UV radiations determine a series of negative effects on the human body, increasing the overall risk of some severe diseases. In this context the protective function of clothes worn during the torrid periods or on snowy winters has a greater importance than ever.
Clothing products create a "barrier" between the skin and the UV solar rays and can provide the most efficient protection through design, type, structure, color and humidity level of the material.
This paper presents the different ways in which clothing products can influence the Solar Protection Factor.

Key words*: ecology, protection, sun, clothing, radiations.*

1. INTRODUCTION

Achieving and continuously improving the ecological function of clothing products is a major requirement, being addressed in both research and production.

The ecological function is in a relationship of interdependence with the comfort functions (thermophysiological and sensorial), the ergonomic function, the safety in use and the availability function. The ecological function expresses the ability of a product to not affect the health and life of the user and to protect the environment by:

- ✓ the product's capacity to withstand the action of contamination factors;
- ✓ product resistance to ignition;
- ✓ product resistance to the action of biological factors;
- ✓ product's ability to degrade in the natural environment.

Depending on the nature of the raw materials used, application of special processing and finishing treatments, the ecological function can be divided into four components, corresponding to its production, product, its maintenance and the possibility of recycling or degradation of the product into the environment [1].

2. UV RADIATION CHARACTERISTICS AND EFFECTS

Solar radiation contains infrared, visible light and ultraviolet radiation. Although ultraviolet radiation (UV) represents only 5% of the solar radiation that reaches the earth's surface, it holds an important role in regard to biology because it has the greatest energy in the optical spectrum.

Taking into consideration the increase in solar activity during the last years and the reduction of the ozone layer, it is primordial to know the effects of ultraviolet radiation on the human body, as well as means of protection against them.

Solar light is electromagnetic energy that propagated through electromagnetic waves. In regards to health, the most important parts of the electromagnetic spectrum are:

- Ultraviolet radiation (UV), invisible to the human eye;
- Visible light enabling us sight;
- Infrared radiation that constitutes the main source of heat, also invisible to the human eye.

UV radiations have enough energy to cause photochemical changes that can initiate biological effects, possibly negative, sometimes referred to as "actinic effects". Solar radiation is heavily deflected by the Earth's ozone layer, limiting terrestrial UV radiation to wavelengths of about 290 nm. Measured UV radiation with a similar response on the human skin, are named erythemic active UV radiation (UVE) [2] and are used to calculate the UV Global Solar Index (UVI), in order to inform the large population. Often it is necessary to monitor total UV radiation, represented by the UVA and UVB component together. On the earth surface UVA radiation usually exceeds the UVB by 15-20 times. Dependent on the biological effects it causes, especially on the DNA, the UV spectrum is divided in radiations: UVA, UVB and UVC. Their characteristics and possible effects on the human body are presented in table 1 and figured 1. In figure 2 is represented the percentage variation of solar protection depending on the value of the solar protection factor (FPS) [2].

Table 1: *Correspondence between UV radiation type and the effects on human body*

UV radiation types	Characteristics and effects of radiation on human body
UVA **Wavelenghts between** **315 – 400 nm**	All of them reach the earth surface. Take part in the tanning process. Can determine photosensitivity to solar rays. Can have effects in the DNA through direct or indirect mechanisms (free radicals) – figure 1. Can have detrimental effects on the skin and eyes. Increase premature skin ageing and the appearence of visible signs (lines, spots, freckles, dry skin).
UVB **Wavelenghts between** **280 – 315 nm**	Partially deflected by the ozone layer. Have detrimental effects especially during the summer months, at mid day (hours 10-16). Increase with 10% per 1000 meters' altitude. Their effects are amplified by reflection on water, sand or snow. Take part in the activation of provitamin D, but can lead to skin lesions, producing burns, genetic mutations and carcinogenesis. Can determine photosensitivity to solar rays.
UVC **Wavelenghts between** **100 – 280 nm**	Absorbed entirely by the atmosphere.

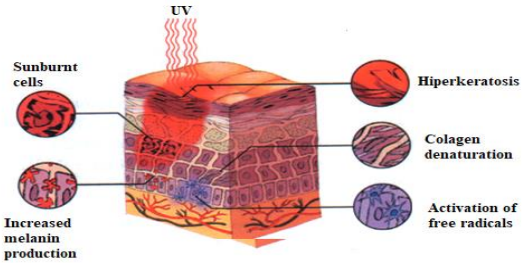

Fig. 1 *UV radiation effects on the skin*

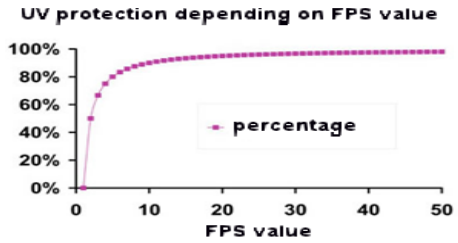

Fig. 2 *Solar protection depending on FPS value*

3. FEATURES THAT INFLUENCE SOLAR PROTECTION

Clothing creates a barrier between the skin and the solar UV radiation and can offer the most efficient protection. While usual clothing offers a feeble protection of only 7%, "anti radiation" clothing products offer a protection up to 97% [3, 4]. In order to protect against radiation, clothing must have inscribed on their label a protection factor of at least 15. The American foundation for skin cancer research recommend clothing with a protection factor of 30, underlining though that those with over 50 factor are the most efficient because only 2% of the ultraviolet radiations can penetrate the attire. In order to evaluate the capacity of a clothing product to offer UV protection, researchers in different countries (Australia, USA, Spain) have established a system of reference indicators: UPF (UV Protection Factor) – evaluates protection against UVA and UVB, and SPF (Sun Protection Factor) that allows evaluating the protection against UVB radiation.

SPF represents the measure of time until the apparition of solar burns on the skin treated with a protection factor. UPF represents the efficiency of a material to block/deflect UV rays, the measurement of transmitted UV radiation being realized with a measuring instrument (Spectrum-radiometer) and an artificial source of light. The results are translated into a mathematical equation based on "erythema active spectrum" (solar burns sustained by an unprotected skin). The reference values of UPF [4, 5] are presented in table 2.

Table 2: *Reference values of UPF*

UPF Value	Protection type	Blocked radiations percentage [%]	Efficiency of penetrant radiation [%]
15 – 24	Good	93,3 – 95,8	6,7 – 4,2
25 – 39	Very Good	95,9 – 97,4	4,1 – 2,6
40 – 50	Excelent	97,5 – 99 +	2,5 – 0
50 +			

From the table above we can see that UPF values are directly proportional with the protective capacity offered by the material or textile product. The efficiency represents the percentage value of radiation that penetrates the clothing. In the case of 2% efficiency products, on the respective label will be inscribed "UPV 50 +". This number attests an almost total protection, when a maximum 2% of radiation can penetrate the clothing.

3.1 Characteristics of clothing products that influence the protection against UV radiation

Clothing products possess specific characteristics that can be managed according to usage conditions, by choosing the characteristics of raw material, structure and structural parameters and finishing processes. Their efficiency against UV radiation is dependent upon [3, 6]:

- clothing design – through coverage degree and adjustment on the body;
- component material – though the fibrous composition and yarn count, type, structure, count, tightness, elasticity, color and humidity degree of the material;
- finishing treatments applied to the fiber, yarn or textile material.

In table 3 is presented the way in which a series of characteristics of the product can influence the protective function again UV radiation.

Table 3: *Influence of textile product characteristics on the protection against UV radiation*

Product characteristics	**UV protection function**
Type and fibrous composition of the yarn	
Cotton, flax	Low protection without additional finishing treatment (optic whitening, thickening, etc.). Unbleached cotton offers a better protection (contains lignin that has the propriety to absorb ultraviolet radiation). Materials that contain mainly yarn of natural cellulosic fibers offer a lower protection against UV, compared to those of protein (silk, wool).
Wool, silk	Moderate protection. By chemical treatment with satinizing substances the protection improves. Satin silk offers an optimal protection because it reflects the solar rays.
Polyamide	Good protection
Polyester	Very good protection because it reflects solar rays. The protection increases with the sheen intensity.
Elastomer	In materials in a relaxed state, the protection is very good because of the thickness degree. In stretched materials the protection decreases significantly because of the reduction of thickness and count.
Structural parameters of the material	
Density, thickness, count, low value mass	Reduced protection, because of reduced covering capacity.
Density, thickness, count, high value mass	Good protection. With the increase of thickness the protection becomes very good (high covering capacity).
Color	
Light colors (white, yellow) or pastel	Low protection. *Example*: a white T-shirt has SPF = 7 – 8, a yellow one SPF = 15, and a red one SPF = 20.
Dark colors (dark blue, black)	Better protection with the darkness of the color or intensity. It was observed that the best protection is offered by dark green or dark blue. Black, dark blue or green velvet has a protection factor UV 50. The type of dye used can modify the UV protection; some dyes can deviate the UV rays and others can increase their absorption. Improving the UV protection can be realized by washing with special detergents (type “Sun Guard” [7]) and by treating the material with chemical substances with screen role against UV.
Humidity	
Any wet or moist material has a vulnerability increased with 50% towards UV rays. Repeated washing and wearing of clothing products can lower the thickness of the material, thus affecting the protective role.	
Tailoring line	
Loose and low degree of body coverage	Low protection
Adjusted and high degree of body	Good and very good protection. In the case of adjusted clothing made out of polyester or polyamide materials is necessary to create models that allow the

Product characteristics	UV protection function
coverage	ventilation of the body (holes, flaps, openings).

3.2 Technical solutions applied to ensure product quality

In order to answer the explosive rise in demand and taking into consideration the ecological problems, research has progressed more and more. The most dynamic sectors are interdisciplinary, combining the research in medicine, textile industry, metrology, transport etc. New generation textiles and "anti-radiation" clothing have become more solicited. Research regarding the improvement of protective functions and ecology of clothing product had as objectives:

Objectives	Accomplishment
• **using of natural fibre** (cotton, flax, silk, wool, etc.) **organically cultivated**, with the capacity to absorb and remove moisture, air penetrable, thermal regulation capacity (cooling sensation, respectively warming according to extern temperature), protection against bacteria and UV protection, contributing to the increase in environment and life quality [8];	**Bamboo fibres** are fabricated out of 100% **bamboo** pulp. Being completely biodegradable and sustainable, the bamboo is the most ecological material of the 21st century. Materials made out of bamboo fibres have antibacterial, anti-allergic, antiperspirant and absorptive proprieties. Articles realized from these material (example – figure 4) are light, nice to touch, natural sheen, don't cause allergic reaction, but protect the skin from UV rays perfectly (reflecting 98% of damaging rays). They have antibacterial proprieties and prevent the development of pathogenic organisms, fungi and acariens (on a bamboo fibre, 70% of bacteria is killed), and keep these proprieties even after a hundred washings. **Articles realized from Cocona (derived from coconut husks).** In figure 5 is presented as example the Power Dry blouse [8], which combines the principles of UV protection improvement and the following characteristics: - Fabricated from Cocona and PES with Polartech Power Dry technology – a material that is part of the Next to Skin category, with absorptive capacity and humidity removal, air permissive and thermal regulation capacity; - Anti-odorizing natural treatment, without involving any chemical antibacterial treatment; - Offers resistance and good protection to UV rays; - Knitted structure type mesh, and the tailoring of the product is adjusted, with a high coverae degree of the body. **The products based on biodegradable vegetable fibers type PLA** (contain poly-lactic acid, polymer extracted from corn) offering a very good protection by blocking the UV rays. **Meryl products** (Rhône Poulenc France – are made out of polyamide PA 6 and PA 6, 6 type fibres. The sheen of Meryl products can be: shiny, semi-matter and ultra- matte. From Meryl type yarn can be realized materials wind and waterproof, with goo thermal isolation, good behaviour in humidity and OV radiation protection. It is used mixed (with wool, rayon, or other types of fibre) with varied systems or yarn under the trademark Nylstar® that has loose and comfort qualities. There have been realized varied fibres Meryl®: Meryl anti UV, offers protection to UVQ and UVB; Meryl Satine, creates a light reflective effect, Meryl Tango, for weaves with a natural silk aspect etc. **MERINO Perform™ products** (23% wool and 77% PES).
• using a mix of natural, ecologic and synthetic fibres that will offer superior quality characteristic tu products and high UV radiation protection;	
• **using ecologic, biodegradable or recyclable fibres,** with antibacterial effects, auto-sterilizing and auto-cleaning, with high UV radiation protection;	
• **using yarn realized through performant technologies** to insure protection against insects, bacteria, fungi and acariens and UV protection;	
• **washing the materials with special detergents** or treating them with chemical substances with UV screen role, but at the same time reducing the waste of chemical treatments.	

In figures 3 - 8 are presented other products with UV protection, intended for children. It is worthy to note that all of them have a high degree of body coverage, for an efficient UV protection.

Fig. 3 *Blouse - (Bambus) UPF 80*

Fig. 4 *Blouse PowerDry - (Cocona si PES) UPF 15*

Fig. 5 *Blouse Montane Bionic (Merino Perform™), UPF 40+*

Fig. 6 *Kids shirt "roto.red" – UPF 80*

Fig. 7 ***"****Deep sea****"*** *trousers (PES 100%) – UPF80*

Fig. 8 *Kids clothing product - UPF 80*

4. CONCLUSIONS

In these conditions of climate changes and increase in solar radiation, the protective function against ultraviolet radiation and thermo-physical comfort of clothing products becomes a priority.
In order to evaluate the capacity of a clothing product to offer UV protection were established systems of reference indicators: UPF – evaluates protection against UVA and UVB representing the efficiency of a material to block/deflect UV rays and SPF (Sun Protection Factor) that represents the measure of time until the apparition of solar burns on the skin treated with a protection factor.
Anti – UV radiation protection exerted by the clothing products is determined by multiple factors presented and analyzed in this paper (fibrous composition of the yarn, compact structure, color and humidity degree of the material, product tailoring line). From this point of view, the clothing preferred must have a higher degree of body coverage, a compact structure, dark colors and not be used in excessive humid places. This paper presents the ways in which clothing products can influence the value of Solar Protection Factor.

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