INNOVATIONS IN UV PROTECTION BY TEXTILES

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<table>
<thead>
<tr>
<th>UV Type</th>
<th>Wavelength (nm)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVA</td>
<td>400-320</td>
<td>max: shares 98.8% of UV reach the ground&lt;br&gt;Can penetrate ozone layer&lt;br&gt;Can penetrate indoor through the window. Sunlamp and salon UV lamp have UV-A</td>
</tr>
<tr>
<td>UVB</td>
<td>320-280</td>
<td>max: shares 1.1% of UV reach the ground&lt;br&gt;Mostly absorbed by ozone on stratosphere, yet it increased because of the damage of ozone&lt;br&gt;The harm to human body is more obvious</td>
</tr>
<tr>
<td>UVC</td>
<td>280-100</td>
<td>Almost zero of UVC reach the ground&lt;br&gt;Absorbed by ozone at high altitude</td>
</tr>
</tbody>
</table>
REASON OF REDUCTION OF OZONE LAYER THICKNESS

✓ Chlorides emissions to the atmosphere caused by freon from:
✓ production and use of several products
✓ volcano eruptions
✓ forest fires
✓ ocean evaporation

According to W. Raab, 1993 Schematic diagram of the effect of chemical UV filters and mineral micropigments.
Melanin - a brown or black pigment, produced in the melanosomes, protects the skin from damaging sun irradiation.
INFLAMMATORY CONDITION

IMMUNOLOGICAL RESPONSE

DNA DEMAGE

REPAIR of DNA

MUTATION

APOPTOSIS

SENSIBILIZATOR

INFLAMMATORY CONDITION

PROTEINS OXIDATION

LIPIDS OXIDATION

ANTIOXIDANT SYSTEM

MULTISTAGE CANCEROGENESIS
RELATIONSHIP OF EXPOSURE TO UVR AND BURDEN OF DISEASE

Advantageous:
- Synthesize vitamin D
- Sterilize and disinfect
- Promote blood circulation
- Invigorate metabolism
- Improve resistance to various pathogenic bacteria

Disadvantageous:
- Red burning
- Promote aging of skin
- Allergy
- Degeneration of fibers in dermis
- Destruction of chromosomes
- Skin CANCER

Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system.

WHO: Health effects of UV radiation
UV PROTECTION BY TEXTILES

UV radiation can be absorbed, reflected, or transmitted through fabrics and fibers. The diagram illustrates the process:

- **Reflection**: Part of the UV radiation is reflected back into the environment.
- **Absorption**: Some UV radiation is absorbed by the fabric or fiber, reducing its intensity.
- **Transmission**: The remaining UV radiation passes through the fabric or fiber.

UV transmission through fabrics and fibers is crucial for understanding how they protect against harmful UV rays.

<table>
<thead>
<tr>
<th>Range of UV protection</th>
<th>UPF</th>
<th>Ranking of UV protection</th>
<th>UV reduction [%]</th>
<th>UV transmittance [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 – 24</td>
<td>15, 20</td>
<td>Good</td>
<td>93.3 – 95.9</td>
<td>6.7 – 4.2</td>
</tr>
<tr>
<td>25 – 29</td>
<td>25, 30, 35</td>
<td>Very good</td>
<td>96 – 97.4</td>
<td>4.1 – 2.6</td>
</tr>
<tr>
<td>40 – 50, 50+</td>
<td>40, 45, 50, 50+</td>
<td>Excellent</td>
<td>97.5 and more</td>
<td>Less than 2.5</td>
</tr>
</tbody>
</table>

The UPF - a ratio of the effective skin-reddening (erythemal) solar ultraviolet radiation (280nm – 400nm) for naked skin to mean effective solar ultraviolet radiation causing reddening of skin covered by the clothing fabric.
RELATIONSHIP BETWEEN PERCENTAGE REDUCTION OF UV RADIATION BY TEXTILES AND VALUE

Source: „Sun protection by numbers...more or less” Robin Marks, University of Melbourne
POSSIBILITIES OF IMPROVING UV PROTECTION BY FABRIC DENSITY (LEFT) AND FIBRE FINISH (RIGHT)
Porosity and Cover Factor of the Fabric

UPF = 40  UPF = 20  UPF = 10
‘MESH’ SIZE AND UPF OF 100% LINEN FABRICS

Linen fabrics with dense structure provide excellent protection against the harmful ultraviolet radiation.
THE VALUES OF TRANSMITTANCE OF THE UVA AND UVB RADIATION THROUGH THE HEMP FABRIC AFTER SUCCESSIVE STAGES OF TREATMENT

Unfinished hemp fabric
UPF = 15, max penetration: 0.058

Hemp fabric after ammonia treatment
UPF = 30; max penetration: 0.033

Hemp fabric after final treatment
UPF = 50; max penetration: 0.0020
WEAVES

Twill

Satin

Herring
THE INFLUENCE OF INTERLACEMENT DEGREE OF DRY AND WET WOVEN FABRICS ON THE UV

UPF of the non-dyed structures in dry conditions

1-5 Twill, 6-11 Plain weaves
12-14 Satin

COTTON FABRIC – TWILL WEAVES

UPF of twill in dry condition according to color

UPF of twills in wet conditions – according to color
APPLICATION OF DYES

Structures of some dyes with good UV absorption

http://www.resil.com/articles/articledevuvprot.htm, D. Gupta
### Benzophenone type

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Chemical Name</th>
<th>Chemical Structure</th>
<th>Features and Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVERSORB 10</td>
<td>2,4-dihydroxy benzophenone</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>Polystyrenes, Unsaturated Polyesters, Polymethacrylated, Rubber-based adhesives, Alkyd and Epoxy coatings etc.</td>
</tr>
<tr>
<td>EVERSORB 11</td>
<td>2-hydroxy-4-methoxy-benzophenone</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>PVC, Unsaturated Polyesters, Acrylics, Rubber, Alkyd resins, Cellulose lacquers and oil paints.</td>
</tr>
<tr>
<td>EVERSORB 12</td>
<td>2-hydroxy-4-n-octoxy-benzophenone</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>PE, PP, PVC, Acrylics.</td>
</tr>
</tbody>
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</thead>
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<tr>
<td>EVERSORB 71</td>
<td>2-(2'-hydroxy-5'-methyl phenyl)-benzotriazole</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>PS, ABS, HIPS, PVC, Acrylic, Polycarbonates and adhesives.</td>
</tr>
<tr>
<td>EVERSORB 73</td>
<td>2-(2'-hydroxy-5'-t-octylphenyl)-benzotriazole</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>PE, PP, PVC, Unsaturated polyesters, PS, ABS and coating systems.</td>
</tr>
<tr>
<td>EVERSORB 74</td>
<td>2-(2'-hydroxy-3',5'-di-t-amylphenyl)-benzotriazole</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>Automotive industrial paints, PP, PVC, PU, Polyester and Acrylic polymers.</td>
</tr>
<tr>
<td>EVERSORB 75</td>
<td>2-(2'-hydroxy-3',5'-di-t-butylphenyl)-5-chloro-benzotriazole</td>
<td><img src="image" alt="Chemical Structure" /></td>
<td>Polyethylene, Polypropylene, Unsaturated polyester, Styrenic polymers.</td>
</tr>
</tbody>
</table>
| EVERSORB 76 | 2-[2-hydroxy-3,5-di(1, 1-dimethylbenzyl)phenyl] 2H-benzotriazole | ![Chemical Structure](image) | 1. Coatings  
2. Polycarbonate  
3. Acrylic  
4. PET |
<table>
<thead>
<tr>
<th>HALS type</th>
<th>Trade Name</th>
<th>Chemical Name</th>
<th>Features and Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EVERSORB 90</td>
<td>Bis-(2,2,6,6-tetramethyl-4-piperidyl)-Sebacate</td>
<td>Superior light stability for PE, PP, ABS, AS, IPS, PU, particularly effective in thick substrates.</td>
</tr>
<tr>
<td></td>
<td>EVERSORB 91</td>
<td>Poly{[6-[(1,1,3,3-tetramethylbutyl)amino]-s-triazine-2,4-diyl] [(2,2,6,6-tetramethyl-4-piperidyl)imino]hexamethylene [(2,2,6,6-tetramethyl-4-piperidyl)imino]}</td>
<td>Polyolefins and various resins, particularly in thin substrates like fibers and films.</td>
</tr>
</tbody>
</table>

Of the inorganic substances with UV absorbing characteristics, **titanium dioxide** deserves special attention – broadband spectrum (reflection, scattering in UVB – UVA regions, visible light and infrared)
NATURAL FIBRE PROPERTIES

- The natural fibres, hemp, flax - the natural pigments, lignin - natural UVR absorbers - good protection

- Hemp fibres - additional ability to dissipate sound wave and optical wave:
  - The horizontal cut section shape - irregular triangle, polygon and lumbar circle
  - The molecular structure - more loose and more prism and whorl

(Inspection report of the Physical Institute of China Academy of Science)
LIGNINS IN NATURAL FIBERS

- Lignin content in flax fibers: 0.6 – 5.0%
  in hemp fibers: 3.5 – 5.5%
- Lignin removal from the fibers during initial processes of fibers preparation
- Possibilities of new lignin application: Use of lignin as UV blockers for fabrics
NANO STRUCTURE LIGNIN

- Use of high quality kraft lignin - separation of lignin from black liquor
- Lignin with nano structure obtained by ultrasonic treatment
International Patent application PCT/PL2007/000025

“Cellulose fibre textiles containing nanolignin, a method of applying nanolignin onto textiles and the use of nanolignin in textile production”

AUTHORS:
1. Prof. dr Ryszard Kozłowski,
2. Dr Eng. Malgorzata Zimniewska
3. Dr Jolanta Batog
DISTRIBUTION OF PARTICLE SIZE OF NANO STRUCTURE LIGNIN

Transmission Electron Microscopy
JEM 1200EX II, Joel
STUDY ON INFLUENCE NANOLIGNIN ON UV PROTECTION

- Padding of nano structure lignin on linen fabric samples
- Concentration of nanolignin in water solution – below 1 g/l
- Remark – a silicone emulsion with different concentration – 5, 25 and 50 g/l, was used for better fixation of the nanolignin particles with the fabric
RESULTS: EFFECT OF LINEN FABRIC COVERED BY NANOLIGNIN ON UPF

![Bar chart showing the effect of linen fabric covered by a solution of nanolignin on UPF.]

- **UPF**
- **Times padding**
- **Linen fabric covered by solution of nanolignin**
- **Raw linen fabric**
EFFECT OF LINEN FABRIC COVERED BY NANOLIGNIN AND SILICONE EMULSION (AFTER 8 PASSAGES) ON UPF

UPF

Concentration of silicone emulsion (g/l)

0 5 20 30 40 50

Linen fabric covered by solution of nanolignin and silicone emulsion

Raw linen fabric covered by solution of nanolignin

Raw linen fabric
EFFECT OF LINEN FABRIC COVERED BY NANOLIGNIN AND SILICONE EMULSION (25 G/L) ON UPF

UPF

Times padding

- Linen fabric covered by solution of nanolignin and silicone emulsion
- Raw linen fabric covered by silicone emulsion
### Antibacterial Properties of UV Blocking of Linen Fabric Covered by Nanolignin

<table>
<thead>
<tr>
<th>Type of Bacteria</th>
<th>Antibacterial Activity</th>
<th>Screening tests acc. to AATCC 147-1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corynebacterium xerosis</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Bacillus licheniformis</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Micrococcus flavus</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Staphylococcus haemolyticus</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Bactericidal activity
CONCLUSIONS (1)

- There are many ways of obtaining good UV protection by textiles, through application of special structure construction, UV absorbers or others.

- Treatment of tested textiles with a solution of nano structure lignin significantly improves the fabric UV barrier properties.

- The nanolignin treatment of textiles does not worsen their physical and bio-physical properties.
Application of nanolignin with silicone emulsion for linen fabrics gives multifunctional product with following properties:

- Excellent UV protection
- Bactericidal activity
- Good electrostatic properties
- High comfort of users

Thanks to lignin application instead of chemical UV absorbers it is possible to reduce chemicals, applied in finishing processes of textiles, and environmental protection.
There is no such thing as a safe tan

FDA publication
Thank you very much for your attention