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**SRL2007-089: DETERMINATION OF THE UV PROTECTION FACTOR
(UPF) FOR A FABRIC SAMPLE**

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- Objective:** To determine the UPF of a fabric sample using AATCC Test Method 183-2000 – before washing, after one wash and after 40 washes
- Test Fabric:** Yellow
- Sponsor:** Sunsoul Inc.
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Procedure:

A sample swatch measuring approximately four inches by four inches was cut from the fabric sample. The specimens were stored for at least 4 hours in a chamber with a constant temperature of 70° ($\pm 2^\circ$) Fahrenheit and a relative humidity of 65% ($\pm 2\%$).¹

The specimen was removed from the chamber and the UPF was determined using a Labsphere UV Transmittance Analyzer. Model UV-1000S, S/N 04040620739, calibrated on January 13, 2006 to NIST traceable standards (Labsphere, North Sutton, NH). Four sites on the sample swatch were chosen and the UV transmission was measured three times on each site. After each measurement the specimen was rotated approximately 45° from the previous measurement orientation for a total of 12 measurements.

The sample was then machine washed once on the gentle, cold setting of an AATCC approved washing machine using the AATCC standard reference detergent WOB. The sample was then tumbled dry on the "Ultra Delicate" setting of an AATCC approved dryer.² The sample swatch was then stored as above and UV transmission measurements were taken as above.

The sample swatch was then machine washed and tumbled dry, with the above settings, an additional 39 times for a total of 40 washings. The sample was then stored as above and UV transmission measurements were taken.

Calculations:

The following equations were used to calculate the UPF, average UVA-range ultraviolet transmittance, average UVB-range ultraviolet transmittance, percent blocking of UVA and percent blocking of UVB of each test fabric³:

For UPF:

$$\text{UPF} = \frac{\sum_{280 \text{ nm}}^{400 \text{ nm}} E_{\lambda} \times S_{\lambda} \times \Delta\lambda}{\sum_{280 \text{ nm}}^{400 \text{ nm}} E_{\lambda} \times S_{\lambda} \times T_{\lambda} \times \Delta\lambda} \quad (1)$$

where:

E_{λ} = relative erythemal spectral effectiveness

S_{λ} = solar spectral irradiance

T_{λ} = average spectral transmittance of the sample (measured)

$\Delta\lambda$ = measured wavelength interval (nm)

For UVA-range transmittance:

$$\tau(\text{UVA})_{\text{AV}} = \frac{\sum_{315 \text{ nm}}^{400 \text{ nm}} T_{\lambda} \times \Delta\lambda}{\sum_{315 \text{ nm}}^{400 \text{ nm}} \Delta\lambda} \quad (2)$$

For UVB-range transmittance:

$$\tau(\text{UVB})_{\text{AV}} = \frac{\sum_{280 \text{ nm}}^{315 \text{ nm}} T_{\lambda} \times \Delta\lambda}{\sum_{280 \text{ nm}}^{315 \text{ nm}} \Delta\lambda} \quad (3)$$

For percent blocking UVA:

$$\% \text{ Blocking UV-A} = 100\% - \tau(\text{UVA})_{\text{AV}} \quad (4)$$

For percent blocking UB-B:

$$\% \text{ blocking UV-B} = 100\% - \tau(\text{UVB})_{\text{AV}} \quad (5)$$

In addition, for labeling of UV-protective textiles the mean UPF for each test specimen and the mean, standard deviation and standard error for all samples are calculated using the following formulas.

For the mean UPF of each sample:

$$MS_{UPF} = \frac{UPF_1 + UPF_2 + UPF_3}{N}$$

For the mean UPF of all samples:

$$UPF_m = \frac{MS_{UPF1} + MS_{UPF2} + MS_{UPF3} + MS_{UPF4}}{N}$$

For the Standard Deviation (SD) of all samples:

$$SD = \sqrt{\frac{\sum_{i=1}^N (UPF_i - \text{mean UPF})^2}{N-1}}$$

For the Standard Error (E) of all samples:

$$E = \frac{T_{\kappa\alpha}SD}{\sqrt{N}}$$

where:

$T_{\kappa\alpha}$ = T variate ($\alpha = 0.005$)
 κ = $N-1$
SD = Standard Deviation
N = number of samples

Determination of UPF Value for Label⁴:

The UPF value to be placed on the label is the mean UPF (UPF_m) minus the standard error (E) of the sample UPFs, the result of which has been rounded down to the nearest multiple of five. If the lowest MS_{UPF} is lower than the UPF_m then the lowest MS_{UPF} will be used as the labeled UPF (not to exceed a value of 50). For obtained UPF values greater than 50, a value of 50+ will be assigned.³

For laundered samples, the lowest obtained $UPF - E$ will be used for labeling purposes.

The following formula is used in calculating the UPF value for labeling:

UPF value for label (a multiple of 5) = $UPF_m - E$

When the calculated UPF is less than 15, the fabric cannot be labeled as UV protective.³

Results

Results are summarized in Tables1-3:

Table 1. UPF Values for the Unwashed Sample

	Test Fabric: Yellow - Unwashed											
	Specimen 1			Specimen 2			Specimen 3			Specimen 4		
Sample UPF value=	163.25	173.72	159.62	197.71	191.33	215.80	190.22	187.51	185.51	159.26	152.08	158.01
MS (UPF)=	165.53			201.61			187.75			156.45		
UPF (m)=	177.84											
SD=	20.59											
E=	30.07											
UPF-E=	147.77											
Labeled=	50 +											
Mean T(UVA)=	0.51%											
Mean T(UVB)=	0.50%											
%Block UVA=	99.49%											
%Block UVB=	99.50%											

Table 2. UPF Values for the Sample Washed Once

	Test Fabric: Yellow - 1 Wash											
	Specimen 1			Specimen 2			Specimen 3			Specimen 4		
Sample UPF value=	247.60	252.32	262.16	238.09	241.75	261.40	246.96	231.12	254.55	257.57	255.62	267.05
MS (UPF)=	254.03			247.08			244.21			260.08		
UPF (m)=	251.35											
SD=	7.13											
E=	10.41											
UPF-E=	240.94											
Labeled=	50 +											
Mean T(UVA)=	0.35%											
Mean T(UVB)=	0.34%											
%Block UVA=	99.65%											
%Block UVB=	99.66%											

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Table 3. UPF Values for the Sample Washed 40 Times

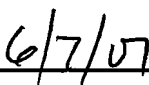
	Test Fabric: Yellow - 40 Washes											
	Specimen 1			Specimen 2			Specimen 3			Specimen 4		
Sample UPF value=	249.66	252.56	245.94	279.05	290.43	288.26	254.00	277.34	258.81	254.65	266.57	249.54
MS (UPF)=	249.39			285.91			263.39			256.92		
UPF (m)=	263.90											
SD=	15.75											
E=	22.99											
UPF-E=	240.91											
Labeled=	50 +											
Mean T(UVA)=	0.36%											
Mean T(UVB)=	0.33%											
%Block UVA=	99.64%											
%Block UVB=	99.67%											

Conclusions:

Sunsoul Fabric Sample "Yellow" had a UPF – E value of 147.77 before washing, 240.94 after 1 washing and 240.91 after 40 washings and may be labeled as UPF 50+.



J. William Stanfield – Investigator



Date

References:

1. Standard Practice for Conditioning and Testing Textiles, ASTM Designation: D 1776-98. ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959 USA.
2. Washer: Kenmore 90 series, Model #110.23902200, Serial #CM0906322. Dryer: Kenmore Elite, Model #110.62952100, Serial #MM0441223.
3. Transmittance or Blocking of Erythemally Weighted Ultraviolet Radiation through Fabrics, AATCC Test Method 183-2000. . American Association of Textile Chemists and Colorists, Research Triangle Park, NC 27709.
4. Standard Guide for Labeling of UV-Protective Textiles," ASTM Designation: D 6603-00. ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959 USA.