UV Application data

Evaluation of sun protection fabrics by using a UPF evaluation system

UPF (UltraViolet Protection Factor) is used to indicate the UV shielding performance of sun protection for fabric products. The 'UPF value' represents the ratio of time for sunburn by UV with and without the protection of the fabric material or product. For example, in the case of skin irradiated by ultraviolet light in 10 minutes with a UPF 50 cloth, it takes 500 min (50 (UPF) x 10 min) to obtain the same amount of sunburn to the skin without using the cloth product. The test method of for UPF calculations when using a UV-Vis spectrophotometer is defined in AS/NZS 4399:1996, BS EN 13758-1:2002, the AATCC Test Method 183:2010, and GBT18830:2009.

In this application data, the evaluation of the UPF, UPF rating, UVA transmittance, and UVB transmittance of sun protection fiber products defined in AS/NZS 4399:1996 by using the UPF calculation system of a UV/Vis spectrophotometer is explained. Also, the fluorescence propertles are explained by using a spectrofluorometer because fabric products sometimes emit fluorescence by UV light irradiation.

<Keyword> UPF, sun protection fiber, AS/NZS 4399:1996, BS EN 13758-1:2002, AATCC Test Method 183:2010, GBT18830:2009

<Measurement System>

- Transmittance spectra measurement

V-750 UV/Vis Spectrophotometer

ISV-922 Integrating Sphere Unit*

VWUP-967 UPF Measurement Program

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* ILV-924 150mmΦ integration sphere is required for to comply with the AATCC Test Method 183:2010.

•3D fluorescence measurement

FP-8500	Spectrofluorometer
FLH-809	Film Holding Block
ESC-842	Calibrated Light Source-WI
ESC-843	Calibrated Light Source-D2

<Calculation Method>

•UPF

UPF is calculated by equation (1).

$$UPF = \frac{\sum_{290}^{400} E(\lambda)\cdot S(\lambda)}{\sum_{290}^{400} E(\lambda)\cdot S(\lambda)\cdot T(\lambda)} \times 100 \qquad (1)$$

E(λ): CIE reference erythema dose spectrum

S(λ): radiation intensity distribution of sunlight

T(λ): diffuse reflectance spectra (%T)

•UPF rating

To calculate the UPF rating, measure the transmittance spectrum at more than four different points for the same sample and round down the value, calculated by equation (2), by 5.

$$UPF\ rating = UPF_{AVE} - E \qquad (2)$$

$$UPF_{AVE} = \frac{UPF_1 + UPF_2 + \cdots + UPF_N}{N}$$

$$E = \frac{t_{k,\alpha}}{\sqrt{N}} \times SD$$

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UPFi: UPF of ith point on a sample

tk,a: The value which provides 0.5 % as the border value of probability of one side in the t distribution

a: Probability of one side (0.005)

k: Degree of freedom (N-1)

$$SD = \sqrt{\frac{\sum_{i=1}^{N}(UPF_i - UPF_{AVE})^2}{N-1}}$$

If the UPF rating is smaller than the minimum of each UPF, the value which is calculated by equation (3) are rounded down by 5.

$$\text{UPF rating} = \text{lowest UPF} \qquad (3)$$

if UPF rating is more than 50, UPF rating is defined as 50+

•UVA transmittance, UVB transmittance

UVA transmittance is calculated by equation (4) by using the average of the transmittance in the range from 315 nm to 410 nm.

UVB transmittance is calculated by equation (5) by using the average of the transmittance in the range from 290 nm to 315 nm.

$$UVA = \frac{T_{315} + T_{320} + T_{325} + \cdots + T_{400}}{18} \qquad (4)$$

$$UVB = \frac{T_{290} + T_{295} + T_{300} + \cdots + T_{315}}{6} \qquad (5)$$

<Sample>

T shirt (black)	polyester 100%
Sports shirt (black)	polyester 100%
Arm cover (black)	rayon 55% polyester 45%

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<Measurement>

•3D fluorescence measurement

3D fluorescence measurements of the samples were conducted using a spectrofluorometer to identify the fluorescence property using excitation wavelengths in the range from 290 nm to 400 nm.

•Transmittance spectra measurement

(1) Baseline measurements were performed using a Spectralon reference tile.

(2) Transmittance spectra measurements were performed at 4 different points in the same sample.

*If fluorescence was observed in the 3D fluorescence measurement, a Fluorescence Cut Filter Block and a Fluorescence Cut Filter (U-330) are required to measure samples which emit fluorescence in the wavelength range from 450 to 650 nm.

<Measurement result>

•Results of 3D fluorescence measurements

Figure 1 illustrates the 3D fluorescence measurement of the T shirt.

No fluorescence was observed for the excitation wavelengths from 290 to 400 nm.

No fluorescence was observed for the sports shirt and arm cover samples.

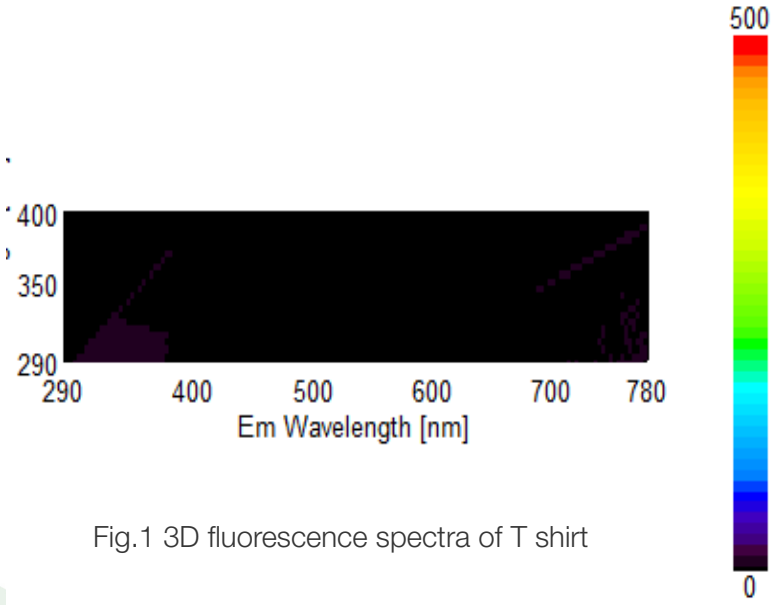

Fig.1 3D fluorescence spectra of T shirt

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•Results of transmittance measurements

Figure 2 shows the transmittance spectrum of each sample.

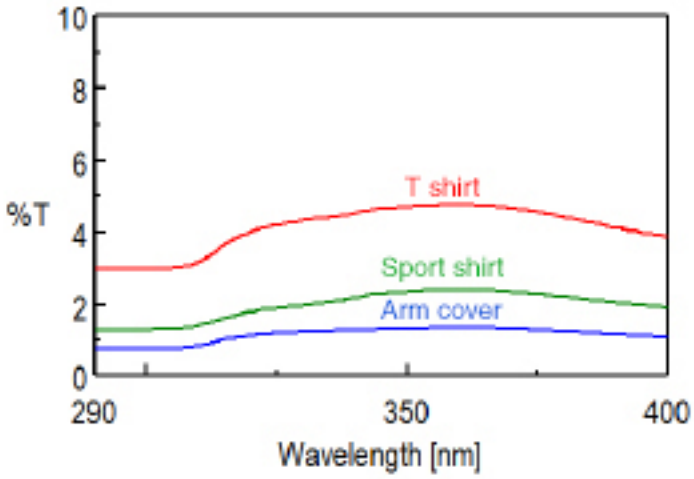

Fig.2 Transmittance spectrum of each sample

<Measurement parameters>

• Spectrofluorometer

Excitation bandwidth	5 nm	Emission bandwidth	5 nm
Scan speed	5000 nm/min	Response	10 msec
Data interval	0.5 nm	Spectra correction	ON

•Spectrophotometer

UV/Vis bandwidth	5.0 nm	Scan speed	100 nm/min
Response	0.96 sec	Data interval	1 nm

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<Analysis result>

Figure 3 illustrates the UPF measurement software display and Table 1 provides the analysis results for the samples. As shown in Figure 3, the [UPF measurement] program can objectively compare the performance of the ultraviolet shielding as a result of the numerical calculation of the UV shielding performance of fabric products. Moreover, the program corresponds to various standards including BS EN 13758-1:2002, AATCC Test Method 183:2010, and GBT18830:2009.

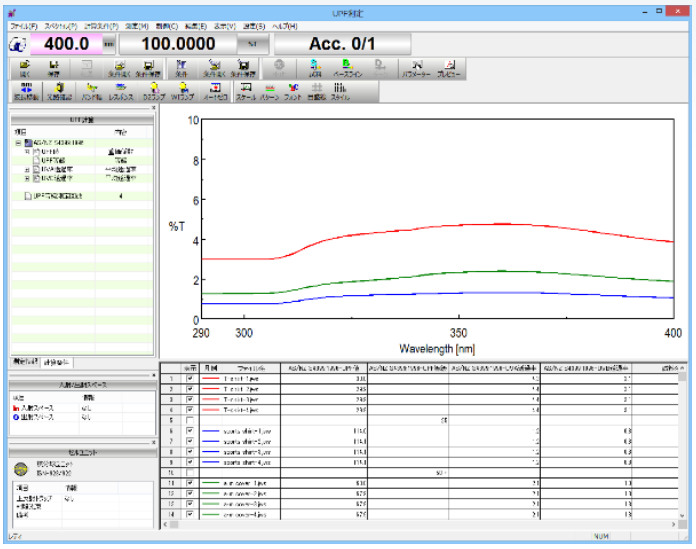

Fig.3 UPF Measurement Program

Table 1 Analysis result based on AS/NZS 4399:1996

Sample	No.	UPF	UPF rating	UVA transmittance[%]	UVB transmittance[%]
T shirt	1	30.0	25	4.4	3.1
	2	30.0		4.4	3.1
	3	30.0		4.3	3.1
	4	30.0		4.4	3.1
Sports shirt	1	114.3	50 +	1.2	0.8
	2	114.2		1.2	0.8
	3	114.1		1.2	0.8
	4	114.4		1.2	0.8
Arm cover	1	68.2	50 +	2.1	1.3
	2	68.0		2.1	1.3
	3	68.1		2.1	1.3
	4	68.0		2.1	1.3

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