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Application News

RF-6000 Spectrofluorophotometer
UV-2600i UV-VIS Spectrophotometer

UPF Evaluation of Fabric Products such as Functional Masks

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User Benefits

- Correct UPF values can be calculated by checking and removing fluorescence in textiles.
- LabSolutions™ UV-Vis UPF calculation software enables automatic calculation of UPF values according to each country's standards after measurement.

■ Introduction

Ultraviolet (UV) radiation is known to cause accelerated aging of the skin, blemishes, freckles, skin cancer, etc. For this reason, there is a high demand for products shielding UV rays, and various manufacturers have developed products claiming "UV protection". To measure the degree to which UV rays are blocked, UPF (Ultraviolet Protection Factor) has been specified as an index (value) by standards set in each country.*1

In this article, we first conducted fluorescence measurements using the RF-6000 spectrophotometer to identify the presence of fluorescent substances affecting UPF values. We then compared various products, such as masks and a type of cap, based on their UPF values calculated using the UV-2600i UV-Vis spectrophotometer and LabSolutions UV-Vis UPF software. Please also refer to Application News No. A601, introducing an example of UPF measurement of clothing.

*1 For the latest standards of each country, please refer to the respective official documents.

Fig. 1 Appearance of RF-6000

■ Measurement of Fluorescence in Fabric Products

In general, white textile products may contain a large amount of fluorescent substances. If such a target sample emits fluorescence, the transmittance of the measured sample will be the combined value of "transmittance + fluorescence," and the calculated UPF will be lower than the original value. Therefore, to check the presence of fluorescent substances in fabric products, we conducted three-dimensional (3D) fluorescence spectrum measurements using the RF-6000 spectrophotometer. For samples, a total of eight samples: six types of masks, a cap, and a towel were prepared. Fig. 1 shows the appearance of the RF-6000, Table 1 shows the measurement conditions, and Fig. 2 shows the obtained results.

Table 1 Measurement Conditions

Instrument	: RF-6000 Solid (powder) sample holder
Excitation (Ex) Wavelength Range	: 280 - 400 nm
Fluorescence (Em) Wavelength Range	: 280 - 550 nm
Data Interval	: Ex 5.0 nm, Em 1.0 nm
Scan Speed	: 30000 nm/min
Spectral Bandwidth	: Ex 5.0 nm, Em 5.0 nm
Sensitivity	: Low

It can be seen from Fig. 2 that No. 1 commercial mask (white) and No. 3 functional mask (white) showed fluorescence around 350-450 nm, while the other samples did not show fluorescence.

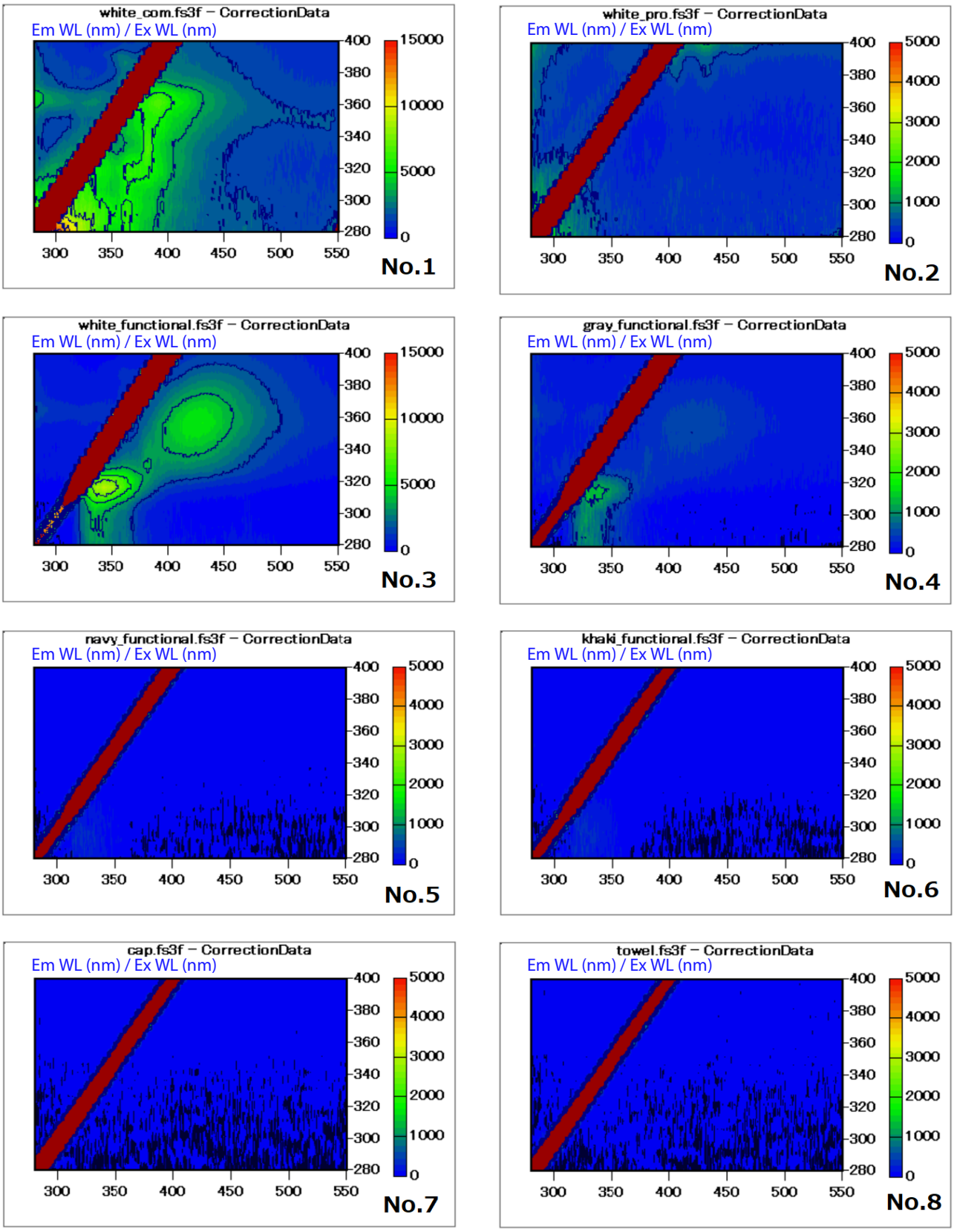

Fig. 2 3D Fluorescence Spectra of Fabric Products
No. 1: Commercial mask (white), No. 2: Professional mask (white), No. 3: Functional mask (white), No. 4: Functional mask (gray)
No. 5: Functional mask (navy), No. 6: Functional mask (khaki), No. 7: Functional cap (black), No. 8: Functional towel (black)

■ Transmission Measurement of Fabric Products

Using the UV-2600i UV-Vis spectrophotometer, we measured the transmittance of eight specimens taken from the eight samples (6 types of masks, cap, and towel), on which fluorescence measurements were conducted. Fig. 3 shows the appearance of the UV-2600i, Table 2 shows the measurement conditions, and Figs. 4 and 5 show the obtained results. In order to remove the influence of fluorescence, a bandpass filter (SIGMAKOKI CO.,LTD. UTVAF-50S-33U) to cut off the wavelengths longer than 431 nm was installed in the optical path after passing through the sample.*2

*2 The baseline was measured under the same conditions as those for the sample measurement, i.e., with the bandpass filter installed.

Fig. 3 Appearance of UV-2600i

Table 2 Measurement Conditions

Instrument	: UV-2600i ISR-2600Plus LabSolutions UV-Vis UPF
Measurement Wavelength Range	: 280 - 400 nm
Data Interval	: 1.0 nm
Scan Speed	: Low
Slit Width	: 5.0 nm
Light Source Switch Wavelength	: 323 nm
Detector Switch Wavelength	: 830nm
S/R Switch	: Inverse

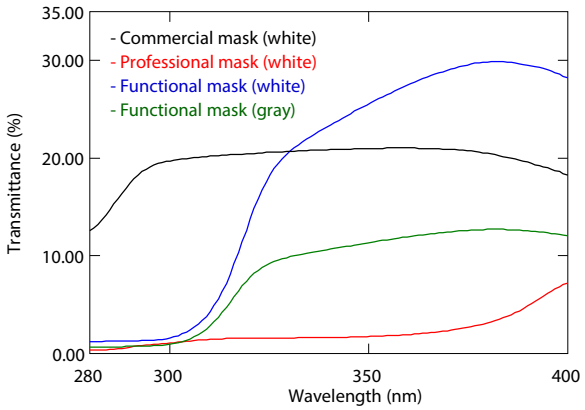

Fig. 4 Transmission Spectra of Fabric Masks (4 Types)

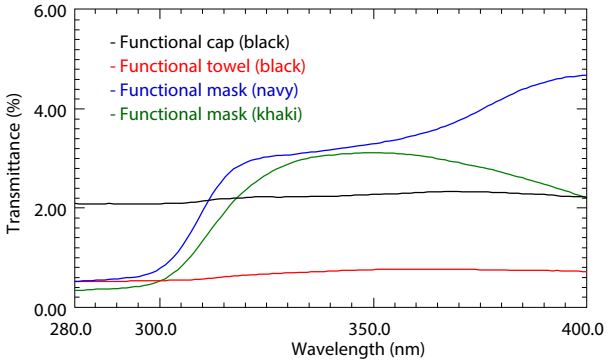

Fig. 5 Transmission Spectra of Functional Fabric Products (4 Types)

It can be seen from Figs. 4 and 5 that the commercial mask (white) and functional mask (white) have a higher transmittance compared to other fabric products.

■ UPF Evaluation on Fabric Products

Ultraviolet radiation is classified into A rays (315 to 400 nm), B rays (280 to 315 nm), and C rays (less than 280 nm), and most of the UV rays falling on the ground are said to be A and B rays. Table 3 shows the results of measuring these regions and calculating the UPF values using the formulas described in the standards of each country. Note that the calculation items and formulas are slightly different for each country's standards. For example, the Japanese Industrial Standards (JIS) calculate the UV shielding rate by including all regions of A and B rays, while the British Standards (EN), German Industrial Standards (DIN), and Australian/New Zealand Standards (AS/NZS) calculate the transmittance of A and B rays individually.

In addition, the standards of each country also specify how to indicate UPF values. Table 4 shows the UPF indication when the calculation results shown in Table 3 are adapted to the standards of each country. Here, the UPF indication was calculated by subtracting the value obtained by multiplying the standard deviation by a constant, from the UPF average value ($UPF_{AVERAGE}$ for EN/DIN, and mean UPF for AS/NZS) shown in Table 3. Note that the constant shown here varies depending on the standards of each country. For details, please refer to the latest official document.

Shimadzu UPF calculation software (LabSolutions UV-Vis UPF) is capable of calculating UPF values according to the following standards in addition to the standards above.*3

1. Standard by American Association of Textile Chemists and Coloris AATCC 183-2014: UPF/UVA/UVB/UV shielding rate (UVA)/UV shielding rate (UVB)
2. Chinese National Standard GB/T 18830-2009: UPF/UVA/UVB

Note also that the UPF value significantly deviates from the average UPF if there is a large variation in values obtained at each sample measurement location. For example, the average UPF value of the professional mask (white) is 61.39, which is higher than 50, but it will be indicated as UPF 35 when converted to the JIS indication.

From Fig. 4, we can see that the commercial mask (white) has very little effect to block UV rays. Furthermore, we found that the effectiveness of functional masks in blocking UV rays was higher in the khaki, navy, gray, and white masks, in that order, and that the effectiveness of the same black color differed between the cap and the towel.

*3 The standards supported by the software are those listed in Table 3 and in the text in this document.

■ Conclusion

The presence of fluorescent substances in fabric products was checked with the RF-6000 spectrophotometer. Based on the results, it was possible to calculate the correct UPF values by removing the effect of fluorescence.

Measurement and analysis were then conducted using the UPF calculation software, LabSolutions UV-Vis UPF. With this software, it is possible to automatically calculate not only the average UPF value required for UPF calculation, but also the UV shielding rate and UVA/UVB values specified in the various countries' standards.

Table 3 Calculation Results of UPF Values according to Different National Standards

Sample	Color	Japanese Industrial Standard JIS L1925-2019		British Standard EN13758-1-2002 / German Industrial Standard DIN EN 13758-1-2007			Australian/New Zealand Standard AS/NZS 4399-2017		
		UPF average	UV shielding rate	$UPF_{AVERAGE}$	$UVA_{AVERAGE}$	$UVB_{AVERAGE}$	mean UPF	mean UVA_{AV}	mean UVB_{AV}
Commercial mask	White	5.54	80.70 %	5.53	19.80 %	17.60 %	5.54	19.80 %	17.60 %
Professional mask	White	61.39	97.30 %	61.13	3.10 %	1.50 %	61.39	3.10 %	1.50 %
Functional mask	White	15.58	80.50 %	15.28	24.50 %	2.60 %	15.58	24.50 %	2.60 %
	Gray	25.18	90.60 %	24.74	11.60 %	2.00 %	25.18	11.60 %	2.00 %
	Navy	54.14	96.90 %	53.5	3.60 %	1.20 %	54.1 4	3.60 %	1.20 %
	Khaki	79.06	97.80 %	78	2.60 %	0.80 %	79.06	2.60 %	0.80 %
Functional cap	Black	46.6	97.70 %	46.57	2.30 %	2.20 %	46.6	2.30 %	2.20 %
Functional towel	Black	168.61	99.30 %	168.21	0.80 %	0.60 %	168.61	0.80 %	0.60 %

Table 4 UPF Indication according to Different National Standards

Sample	Color	JIS L1925-2019 UPF rating	EN17258-1-2002 UPF	AS/NZS 4399-2017 Rated UPF
Commercial mask	White	Not applicable	UPF 5	-
Professional mask	White	UPF 35	UPF 44	UPF 30
Functional mask	White	Not applicable	UPF 14	-
	Gray	UPF 20	UPF 24	UPF 15
	Navy	UPF 45	UPF 48	UPF 30
	Khaki	UPF 50+	UPF>50	UPF 50+
Functional cap	Black	UPF 35	UPF 40	UPF 30
Functional towel	Black	UPF 50+	UPF>50	UPF 50+

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