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Application News

UV-2600i/UV-3600i Plus/SolidSpec™-3700i UV-VIS Spectrophotometers

Regulatory Calculations Using the Spectral Evaluation Function: Evaluating Spectacle Lenses as Specified by JIS T7333

Akari Goto and Kazuki Sobue

User Benefits

- Using the spectral evaluation function, a spectral sum-of-products can be calculated utilizing user-specified weighting factors.
- This enables evaluations compliant with various regulations utilizing spectral sum-of products calculations.

■ Introduction

Some regulations utilizing spectrophotometers specify that spectral transmittance or spectral reflectance values are calculated by multiplying the measured values with weighting factors. LabSolutions™ UV-Vis, a program used to control Shimadzu UV-VIS spectrophotometers, can be used in conjunction with optionally available software to automatically perform color, solar reflectance/transmittance and other predetermined calculations. It can also be used to assign user-specified weighting factors.

User-specified weighting factors can be configured by clicking [Customize*1] within the LabSolutions UV-Vis spectral evaluation function. Calculations and evaluations can then be performed using the weighting factors specified in regulations.

This article describes an example of the use of UV-2600i to measure spectral transmittance values for various spectacle lenses, as well as the utilization of user-defined values to calculate four criteria values*2 specified in JIS T7333.

*1 LabSolutions UV-Vis Daylight or LabSolutions UV-Vis UPF, both optionally available programs, are required to use this function.

*2 JIS T7333 specifies four criteria for clear lenses that are not intentionally tinted, as described in this article. It also specifies various other test methods for spectacle lenses, including Q values (the relative luminosity attenuation rate for recognition and discovery of incandescent traffic signal lights) and P values (polarization efficiency).

■ Spectral Measurements of Spectacle Lenses

The spectacle samples used for these measurements are shown in Fig. 1. Spectacle samples from the same manufacturer are tagged with the same letter. Fig. 2 shows an example of how the spectacle lenses were mounted in the MPC-2600A multipurpose large sample compartment. The measurement conditions are indicated in Table 1. Considering that the lens position relative to the eye can vary during actual use, each lens was remounted and measured three times.

Fig. 1 Spectacle Lenses Measured

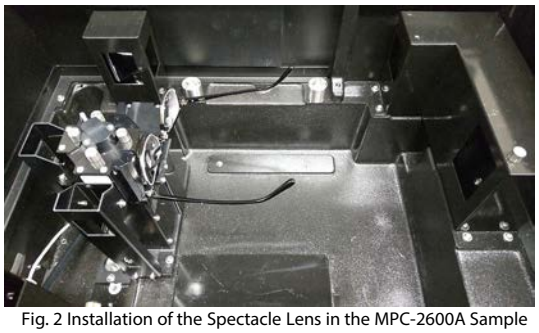


Fig. 2 Installation of the Spectacle Lens in the MPC-2600A Sample Compartment

Table 1 Measurement Conditions

Instruments	:	UV-2600i, MPC-2600A
Measurement Wavelength Range	:	280 - 780 nm
Data Interval	:	1.0 nm
Scan Speed	:	Medium speed
Slit Width	:	5.0 nm
Light Source Switching Wavelength	:	315 nm

Results from the first measurements are shown in Fig. 3. In addition, an enlargement of the UV light range (280 to 380 nm) from Fig. 3 is shown in Fig. 4.

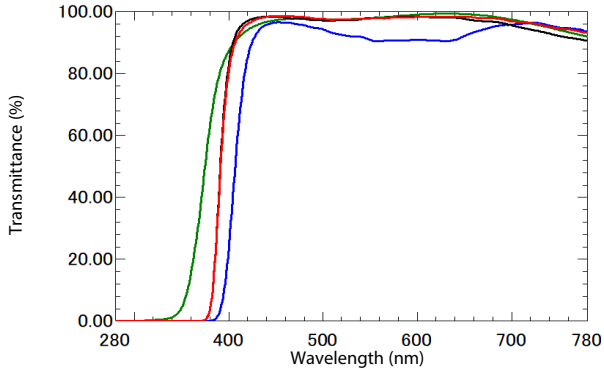


Fig. 3 Transmission Spectra of the Spectacle Lenses

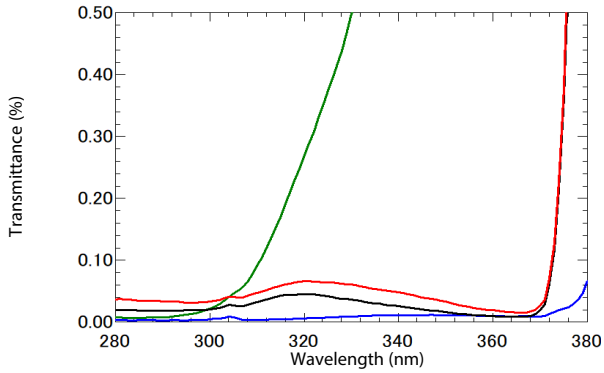


Fig. 4 Enlargement of UV Range (280 to 380 nm) from Fig. 3

Fig. 3 shows that transmission through all the spectacle lenses decreased at shorter wavelengths starting from about 400 nm, and that almost no light was transmitted in the UV region. Fig. 4 shows that only spectacle lens C1 had a transmittance value of 0.1 % or higher, especially in the region from 310 to 370 nm, indicating that C1 produces less UV filtering than the other lenses. Furthermore, the transmittance values in the UV region indicate that the UV protection level of the other lenses can be ranked in the order B1 > A1 > A2.

The next section describes how the above-mentioned results were used to quantitatively evaluate the four criteria values specified in JIS T7333.

■ Evaluations Using the Spectral Evaluation Function

Fig. 5 shows the settings window displayed by selecting [Customize] (marked (1) in Fig. 5) in the program's LabSolutions UV-Vis spectral evaluation function. In this window, the user can specify various weighting factors for the summing of products of measured values depending on the objective. Criteria values are calculated by using the weighting factors to calculate a weighted mean based on equation (1).

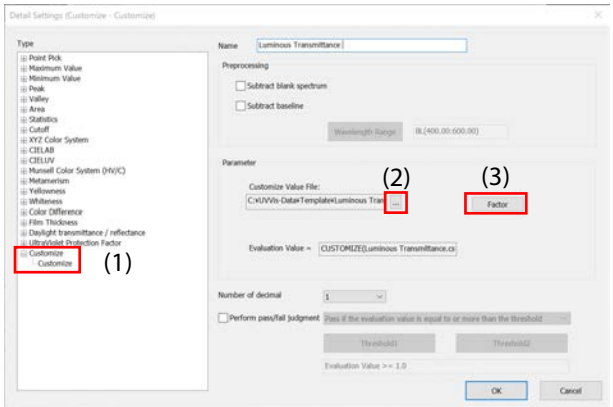
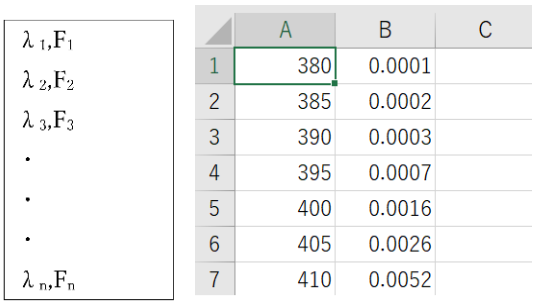


Fig. 5 Window for Configuring User-Defined Settings within the Spectral Evaluation Function

$$Criterion = K_1 \times \frac{\sum D(\lambda)F(\lambda)}{\sum F(\lambda)} \qquad \text{Eq. (1)}$$

D(λ): Measured values
$F(\lambda)$: Weighting factor at each wavelength (λ)
K_1: Coefficient

The preliminary $F(\lambda)$ values are used to create a CSV file with the format shown in Fig. 6. (Fig. 6(a) shows an example of the values generated by specifying one weighting factor.) Criteria values are calculated by clicking icon (2) in Fig. 5 to open this CSV file, and clicking icon (3) in Fig. 5 to set the K_1 value.



λ_1, F_1
λ_2, F_2
λ_3, F_3
.
.
.
λ_n, F_n

	A	B	C
1	380	0.0001	
2	385	0.0002	
3	390	0.0003	
4	395	0.0007	
5	400	0.0016	
6	405	0.0026	
7	410	0.0052	

(a) Format of CSV File
(when one weighting factor is specified)

(b) Example of CSV File

Fig. 6 CSV File Format and Example

■ Calculating the Four Criteria Values Specified in JIS T7333

The criteria values in Table 2 for the four spectacle lens samples indicated above were calculated based on JIS T7333:2018 "Ophthalmic optics – Uncut finished spectacle lenses – Transmittance specifications and test methods." The τ_{SUVA}, τ_{SUVB}, and τ_V values were calculated using the respective weighting factors specified in JIS T7333. Note that τ_{UVA} was calculated from τ_{SUVA} using the statistics-average value from the spectral evaluation function. The calculation results are shown in Table 3.

Table 2 JIS T7333 Criteria Values

τ_{SUVA}	:	Solar UV-A transmittance (%)	315 to 380 nm
τ_{SUVB}	:	Solar UV-B transmittance (%)	280 to 315 nm
τ_V	:	Luminous transmittance (%)	380 to 780 nm
τ_{UVA}	:	Mean UV-A transmittance (%)	315 to 380 nm

Table 3 JIS T7333 Criteria Calculation Results

	τ_{SUVA} (%)	τ_{SUVB} (%)	τ_V (%)	τ_{UVA} (%)
A1	0.158	0.034	97.20	0.142
A2	0.224	0.047	97.91	0.209
B1	0.011	0.005	91.57	0.012
C1	9.721	0.092	98.13	13.81

A comparison of the respective solar UV-A (315 to 380 nm) criteria values, τ_{SUVA} and τ_{UVA}, for each spectacle lens confirmed that B1 < A1 < A2 < C1. Given that solar UV-A from sunlight can cause cataracts if they reach the crystalline lens or retina, these results show quantitatively that choosing eyewear with a low τ_{SUVA} or τ_{UVA} value, such as B1, can provide appropriate protection for the eyes. In contrast, τ_{SUVB}, the criterion used to evaluate the more energetic and eye-damaging solar UV-B (280 to 315 nm) was 0.1 % or less for all the spectacle lenses.

Luminous transmittance τ_V values were calculated for the visible light range from 380 to 780 nm. Transmittance was 80 % or higher for all the spectacle lenses, which confirmed that they are all in luminous transmittance category 0 (transparent with no or slight tint).

■ Conclusion

Calculating the four criteria values specified in JIS T7333 "Ophthalmic optics – Uncut finished spectacle lenses – Transmittance specifications and test methods" using the spectral evaluation function enabled the quantitative evaluation of UV protection and visible light transmittance levels for these lenses. Weighting factors can be freely specified with the user-defined settings in the spectral evaluation function in order to evaluate weighted mean values as specified in a variety of regulations.

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