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Application News

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Spectrophotometric Analysis

Emission Spectrum Measurement for LED Lamp by the UV-2600 UV-VIS Spectrophotometer

A variety of light sources used for general illumination, including incandescent bulbs, fluorescent lights, and light-emitting diode bulbs (LED bulb, below) are currently available on the market. Light bulbs are also available in many colors, including warm white, natural white color and cool white, and are being used in accordance with the specific living environment.
The brightness and color of the illuminating light is determined by the sum of all the monochromatic radiation emitted from the light source. The spectrum obtained from measurement of the intensity of each wavelength of radiated light is called an emission spectrum, and when the emitted colors differ depending on the light source, those emission spectra will also differ. Therefore, it can be assumed that during development of a new light source for general illumination, examination of the emission spectrum generated is extremely important.
We conducted measurement of the emission spectra of several LED bulbs using the UV-2600 ultraviolet visible spectrophotometer, and report here on their spectrum profiles and light distributions.

Emission Spectrum Measurement Accessory

After connecting the emission spectrum measurement accessory to the UV-2600, we measured the emission spectra of the LED bulbs. The measurement accessory is shown in Fig. 1. One end of the optical fiber is installed in the light source compartment of the spectrophotometer. The light emitted from the bulb travels through the optical fiber and monochromator to reach the detector, where the intensity is measured. Here, we conducted measurement of 7 types of commercially available LED bulbs (4 types of warm white bulbs, 3 types of natural white bulbs).
An illuminated warm white bulb and a natural white bulb are shown in Figures 2 and 3, respectively. As is evident from the photographs, one of the bulbs generates a yellowish white color, while the other displays a vivid cool white color tinged with blue. Measurement was conducted with the tip of the optical fiber positioned about 1 cm directly above the bulb. In an actual measurement, the bulb and optical fiber are covered using a blackout curtain.

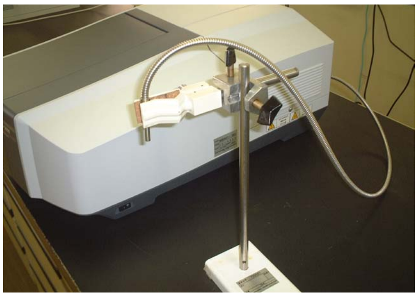

Fig. 1 UV-2600 and Emission Spectrum Measurement Accessory

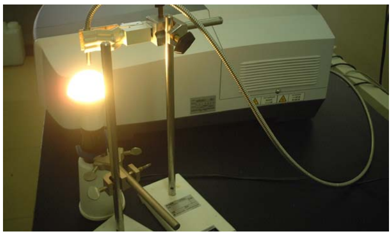

Fig. 2 LED Lamp with a Warm White Color

Fig. 3 LED Lamp with a Natural white Color

Measurement Results

(1) Emission Spectrum Measurement
We conducted measurement of the emission spectra generated by the 4 types of warm white colored LED bulbs (A, B, C, D) and 3 types of natural white colored bulbs (E, F, G)[1]. The wattages of the LED bulbs were 4 W–8 W. The measurement results for A, B, C and D are shown in Fig. 4, and those for E, F and G are shown in Fig. 5[2]. The analytical conditions are shown in Table 1. In Fig. 4 and Fig. 5, two major peaks are seen at the short-wavelength side at about 450 nm, and at the long-wavelength side at about 580 nm, respectively. These correspond to the blue system colors in the former, and yellow system colors in the latter.
Comparing the results of A, B, C, D with those of E, F, G, the long-wavelength side peaks of A, B, C and D are higher ratio-wise than the respective short-wavelength side peaks. From this, it is clear that A, B, C and D became a yellow-tinged white color due to the greater influence of the long-wavelength side peaks, while E, F and G became a blue-tinged white color due to the greater influence of the short-wavelength side peaks. Furthermore, the long-wavelength 580 nm peaks of all of samples occupy nearly the same position, while the positions of the shorter wavelength peaks in the 450 nm region vary somewhat depending on the sample. The peak wavelengths of both the short-wavelength and long-wavelength sides are shown in Table 2. From this, it is evident that in contrast to the 13 nm wide scattering of the short-wavelength peak positions, the positions of the long-wavelength peaks are grouped within a narrow range of 3.5 nm. The above data are expressed in the xy color space (CIE chromaticity diagram) of Fig. 6[3]. The xy chromaticity diagram expresses the hue and saturation of the samples. In this xy chromaticity diagram, the area in the vicinity of groups A, B, C, D and E, F, G corresponds to white (achromatic, neutral). Here, the further the focus shifts to the surrounding areas, the more vivid the colors become. Fig. 6 indicates that the LED bulbs of the A, B, C, and D group are yellowish white in color, and that the natural white colored bulbs of the E, F, and G group are bluish white.

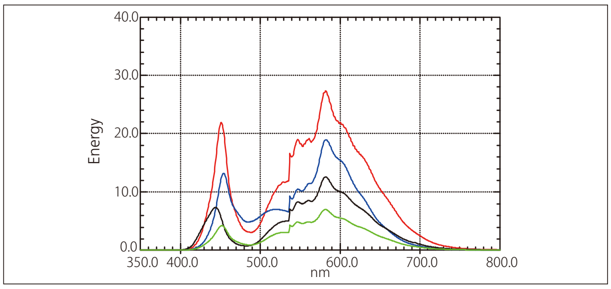

Fig. 4 Emission Spectra of A, B, C and D Having a Warm White Color (Blue: A, Green: B, Red: C, Black: D)

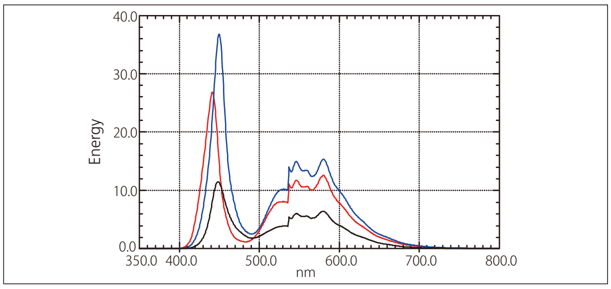

Fig. 5 Emission Spectra of E, F and G Having a Natural white Color (Blue: E, Red: F, Black: G)

Table 1 Analytical Conditions

Instrument	: Shimadzu UV-2600 UV-VIS spectrophotometer Emission spectrum measurement accessory
Measurement	: 350-800 nm
Scan Speed	: Fast
Sampling Pitch	: 0.5 nm
Photometric Value	: Energy
Slit Width	: 2 nm
Gain	: 4

Table 2 Peak Wavelengths

	Short-Wavelength Side (nm)	Long-Wavelength Side (nm)
A	454.0	582.5
B	452.0	581.5
C	451.0	582.0
D	443.5	582.0
E	449.5	580.0
F	441.0	580.0
G	448.5	579.0

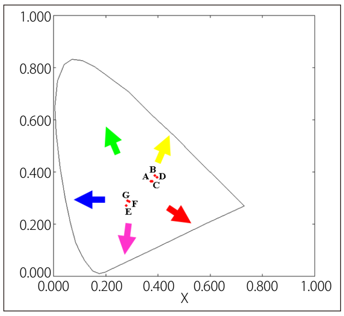

Fig. 6 xy Color Space

(2) Comparative Directional Emission Spectrum Measurement

Next, to verify the light distribution of the samples, we measured the emission spectra with the optical fiber positioned at different angles as shown in Fig. 7, specifically, directly above (0 °), at an angle (45 °), and directly lateral (90 °) with respect to the bulbs. The results for sample A and sample B are shown in Fig. 8 and Fig. 9, respectively. With sample A, the emission spectra intensity decreased as the fiber mounting angle became larger. On the other hand, with sample B, the emission spectrum intensity is greater at 45 ° than at 0 °, but it is presumed that this decrease in emission intensity might be due to partial blocking of the light due to the presence of characters printed on the top of the bulb. It should be noted that no printing is present on sample A.

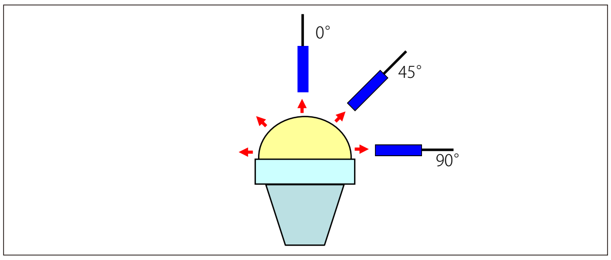

Fig. 7 Comparative Directional Emission Spectrum Measurement

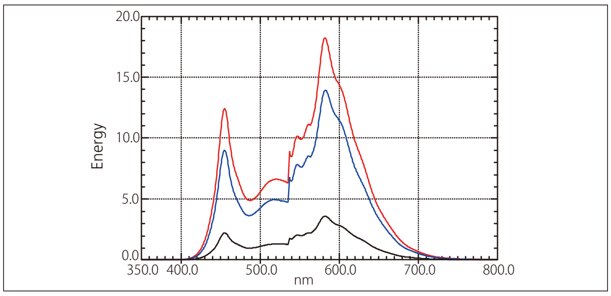

Fig. 8 Direction-Specific Emission Spectra of Sample A (Red: 0 °, Blue: 45 °, Black: 90 °)

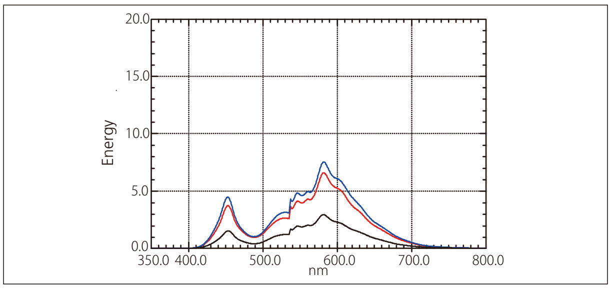

Fig. 9 Direction-Specific Emission Spectra of Sample B (Red: 0 °, Blue: 45 °, Black: 90 °)

Summary

The emission spectra of various types of LED bulbs were measured using an emission spectrum measurement accessory, and the results indicated that the intensities and profiles of the spectra varied depending on the bulb. The spectrum profile relates to the color rendering properties of the light source, and is important to the investigation of the light source properties. It was also found that the emission intensity varies depending on the direction from which the light is radiated from the light source. Use of the emission spectrum measurement accessory enables comparative investigation of various types of illumination sources.

1) The obtained emission spectrum depends on the instrumental function of the spectrophotometer. In order to obtain a true emission spectrum, the instrumental function must be obtained using a standard light source, and the measured emission spectrum is corrected using the instrumental function. However, the intensity of the corrected emission spectrum then becomes the relative intensity.
2) The 536 nm step is due to switching of the filter in the spectrophotometer.
3) The emission spectral data was displayed by first converting the data to text format, and then using color measurement software for display.

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