Application Note

FP-0006

Phosphorescence Spectrum Measurement for Quantum Efficiency

1. Introduction

Phosphorescence substances have attracted attention as luminescent material for organic EL device. Quantum efficiency of phosphorescence substances is required for developing such materials. Although the conventional integrating sphere measures sample spectrum at room temperature, phosphorescence is observed by cooling the sample to the temperature of liquefied nitrogen at 77K. JASCO developed a new dedicated system for calculating quantum efficiency from the measured phosphorescence spectra at 77K.

2. Phosphorescence Quantum Efficiency Measurement System

FP-6500 Spectrofluorometer
100-mm Cooling Integrating Sphere
FWSQ-6017 Quantum Efficiency Calculation Program

Sample: solid (6 to 7mm sq × 1.0 to 1.5mm tick)
powder
liquid

Figure 1: Phosphorescence Quantum Efficiency Measurement System

3. Measurement Procedure to Calculate Quantum Efficiency

Quantum efficiency is obtained by the ratio between "photon number absorbed by sample" and "photon number emitted by sample". To measure phosphorescence spectra with an integrating sphere for the calculation, first, place a Dewar vessel with coolant such as liquefied nitrogen in the sphere and measure a spectrum of incident light as illustrated in Fig. 2-a. The peak area appears in the Ex wavelength range of the spectrum, illustrated with blue in Fig. 3, indicates incident photon number S_0. Then, place a sample inside the vessel and measure a spectrum including scattering light of incident light and sample emission as illustrated in Fig. 2-b. The peak area appears in the Ex or Em wavelength range of the spectrum, illustrated with red in Fig. 3, indicates photon number unabsorbed by sample S_1 or emitted by sample S_2, respectively. The quantum efficiency is calculated from "photon number absorbed by sample = S_0 - S" and "photon number emitted by sample S_2":

$$\text{Quantum Efficiency} = \frac{\text{Photon number emitted by sample}}{\text{Photon number absorbed by sample}} = \frac{S_2}{S_0 - S_1}$$

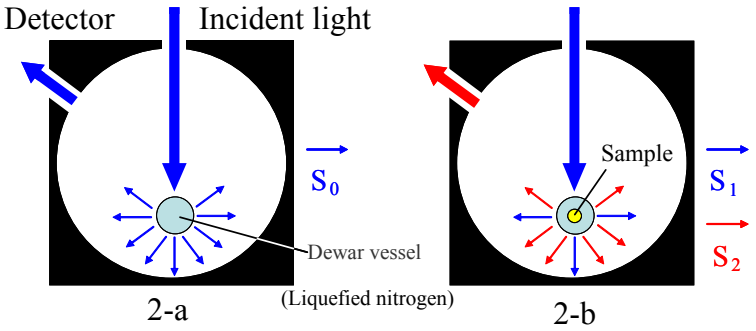

Figure 2 Sample position in the integrating sphere

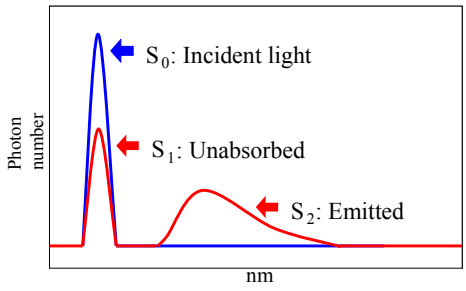

Figure 3 Model spectra

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4. Fluorescence Quantum Efficiency of Quinine Sulfate

To confirm whether placing the Dewar vessel and coolant[*1)] in the sphere has any effect on the measurement results, quinine sulfate with well-known fluorescence quantum efficiency was measured by using this system. Fig. 4 illustrates the measured spectra and Table 1 shows the calculation results of quantum efficiency (ϕ). The calculated fluorescence quantum efficiency was 0.56 that corresponds well with the literature-based value of 0.546[*2)]. From this calculation results, the effect of placing vessel inside the sphere can not be confirmed.

<Measurement Parameters>

Ex bandwidth	5 nm	Em bandwidth	5 nm	Response	0.5 sec
Ex wavelength	350.0 nm	Data interval	1 nm	Scan speed	1000 nm/min

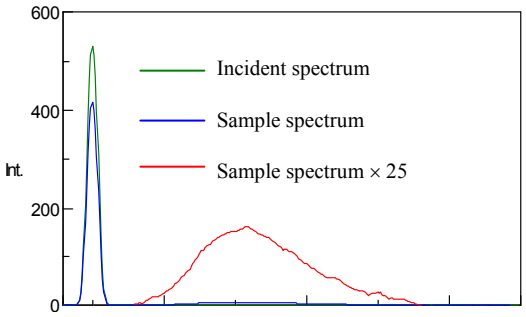

Figure 4 Spectra of Quinine Sulfate

	Int.
S_0	5377.3
S_1	4092
S_2	715.4
Φ [Measured]	0.56
Φ [Literature][*2)]	0.546

Table 1 Fluorescence quantum efficiency of quinine sulfate

[*1)] In this measurement, the Dewar vessel was filled with water instead of liquid nitrogen

[*2)] Melhuish, W.H., J.Phys.Chem. **65**, 229, 1961

5. Phosphorescence Quantum Efficiency of Benzophenone

Benzophenonewas was measured as a representative phosphorescence substance. The sample was cooled by liquefied nitrogen. Fig. 5 llustrates the measured spectra and Table 2 shows the calculation results of quantum efficiency (ϕ). The calculated phosphorescence quantum efficiency was 0.93 that corresponds well with the literature-based value of 0.9[*3)].

<Measurement Parameters>

Ex bandwidth	5 nm	Em bandwidth	5 nm	Response	0.5 sec
Ex wavelength	335.0 nm	Data interval	1 nm	Scan speed	1000 nm/min

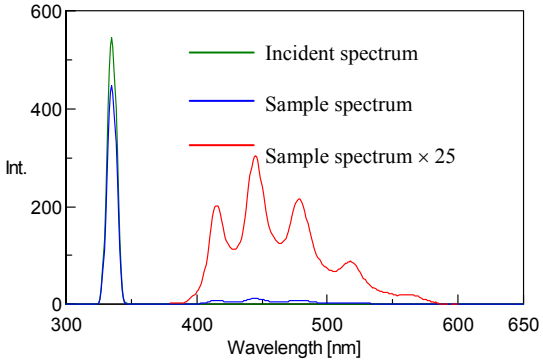

Figure 5 Spectra of Benzophenone

	Int.
S_0	4954.3
S_1	4074.0
S_2	819.3
Φ [Measured]	0.93
Φ [Literature][*3)]	0.9

Table 2: Phosphorescence quantum efficiency of Benzophenone

[*3)] The chemical society of Japan, Courses in Experimental Chemistry 3 basic physical chemistry, Maruzen ISBN: 4-621-07303-6

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