Absolute PL Quantum Yield Spectrometer

Quantaurus-QY®

HAMAMATSU

PHOTON IS OUR BUSINESS

Quantaurus-QY was developed as a compact, easy-to-use system with a small footprint based on Hamamatsu's established C9920-02,-02G/03,-03G systems for measuring absolute photoluminescence quantum yields. Operating this system is simple. Load a sample and press the start button to measure the photoluminescence quantum yields, excitation wavelength dependence, PL excitation spectrum and other properties in a short time.

QY Absolute PL Quantum Yield

Measuring absolute photoluminescence quantum yields (internal quantum efficiency) of light-emitting materials

In developing new light-emitting materials, it is essential to improve their photoluminescence efficiency.

Improving this efficiency requires accurate techniques for measuring the quantum yield*. Quantaurus-QY includes an excitation light source consisting of a xenon lamp and a monochromator, an integration sphere with optional nitrogen gas flow, and a multichannel detector capable of simultaneous multi-wavelength measurement, which are all integrated into a single package. The system utilizes dedicated software for making the measurements. The detector is a cooled, back-thinned CCD sensor and so makes instantaneous measurements with high sensitivity.

Quantaurus-QY handles solution, thin-film and powder samples, and it can cool solution samples down to liquid nitrogen temperature.

* Ratio of the number of photons emitted by photoluminescence to the number of photons absorbed by the light-emitting material.

Features

- **Measures absolute photoluminescence quantum yield of light-emitting materials (PL measurement)**
- **Utilizes an integrating sphere to measure all luminous flux**
- **Cooled, back-thinned CCD sensor allows measurements with ultra-high sensitivity and high S/N ratio**
- **Automatically controls the excitation wavelengths**
- **Space-saving, compact design**
- **Wide selection of analysis functions**
  - Photoluminescence quantum yield measurement
  - Excitation wavelength dependence
  - Photoluminescence spectrum
  - PL excitation spectrum

Instantaneous measurement

The multichannel detector captures the sensitivity-compensated spectrum, and calculates the quantum yield in a process that instantaneously finds the absolute value of the quantum yield.
Dialog-style dedicated software keeps the measurement process simple.

Fully automated hardware

The software-controlled monochromator allows selecting excitation wavelengths so that the sample can be excited by various excitation wavelengths. Wavelength dependence of quantum yields and excitation spectrum can then be automatically measured.

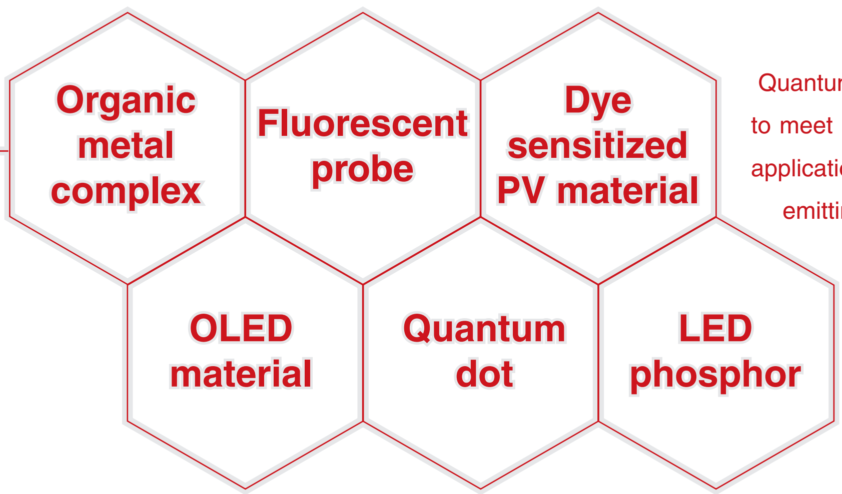
Analyzing diffrent sample forms

Quantaurus-QY handles solution, thin-film, and powder samples. With a Dewar flask holder, solution samples can be cooled by liquid nitrogen to -196 ˚C (77K).

2 models available

Two product types are provided according to the wavelength range for sample excitation and photoluminescence: one covers a spectral range from 300 to 950 nm and the other from 400 to 1100 nm.

Standard	NIR
C11347-11	C11347-12
wavelength 300 nm to 950 nm	wavelength 400 nm to 1100 nm



Quantum yield measurements are made in a wide range of fields to meet needs in development and research applications. Typical applications include improving quality in various types of light-emitting materials such as organic EL materials, white LED, and phosphors for FPD; researching organic metal complexes; evaluating fundamental characteristics of dye-sensitized solar cells; and measuring fluorescent probe efficiency in biological fields.

Principle of quantum yield measurement

Measurement of reference
(only for quartz cells)

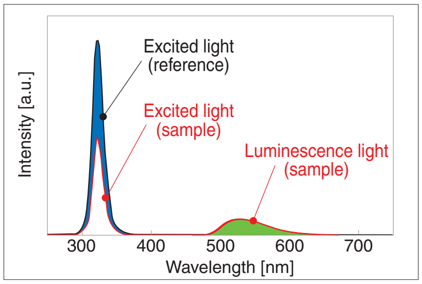
↓

Measurement of sample
(quartz cells containing sample solution)

↓

Calculation of photoluminescence quantum yield

$$\text{Photoluminescence quantum yield} = \frac{\text{Number of photons emitted as photoluminescence from sample}}{\text{Number of photons absorbed by sample}}$$



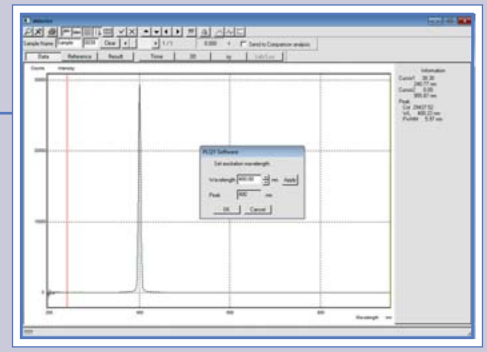
▲ Excitation light on reference and sample and photoluminescence spectrum measurement example

Measurement procedure

The dedicated software ensures simple and rapid measurements.

Select excitation wavelength

Input excitation wavelength



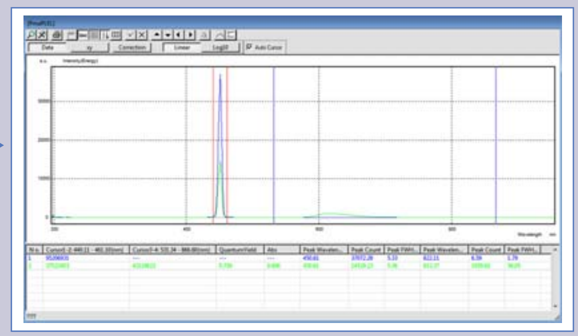
Auto-set measurement condition

Load sample

Sample: solution, powder, solid, thin-film

Measure reference and sample data

Measurement data



Analysis

Measurement results of a standard sample, i.e. anthracene solution, are obtained within about 60 seconds after starting sample measurement.

Displays the analysis results as:
Photoluminescence quantum yield and peak emission

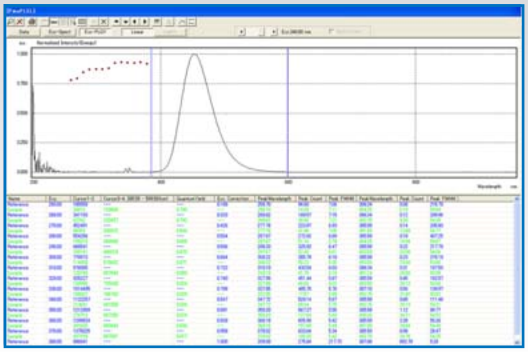
Specimens can be analyzed manually.

- Display emission spectrum
- Count chromaticity
- Plot excitation-wavelength dependence of photoluminescence quantum yield
- Display excitation spectrum

Analysis functions

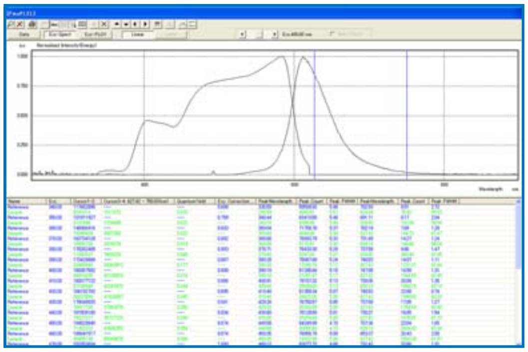
Simple-to-use dedicated quantum yield measurement software

Dependence on the excitation wavelength



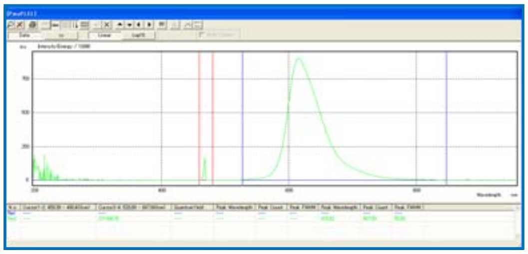
This screen shows the dependence of PL quantum yield on excitation wavelength.

PL excitation spectrum



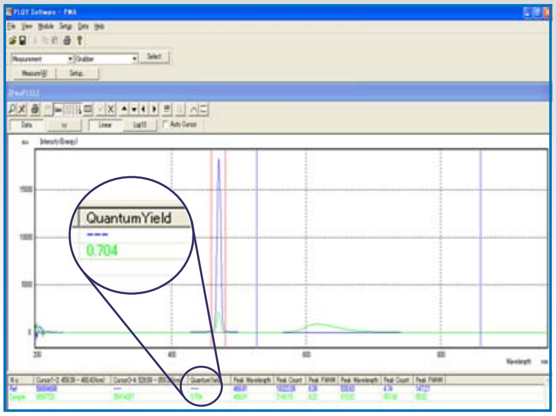
Excitation spectra can be measured by using a motorized excitation monochromator.

PL spectrum



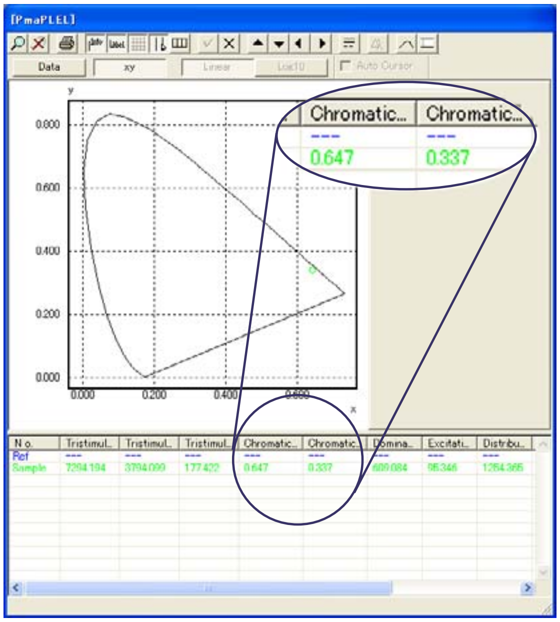
A PL spectrum is displayed after subtraction of residual excitation light components. A spectrum measured by Quantaurus-QY always contains excitation light which was not absorbed by the sample. The software offers a function for removing these remaining excitation light components and enables the user to show a purified emission spectrum.

PL quantum yield measurement



This is a basic screen for quantum yield measurements. The luminescence quantum yield is automatically calculated after measurement. Excitation and emission bands are defined by adjusting the cursors. The value of the quantum yield is displayed in the table below the spectrum next to emission intensities, peak wavelength, peak counts, and peak band (FWHM).

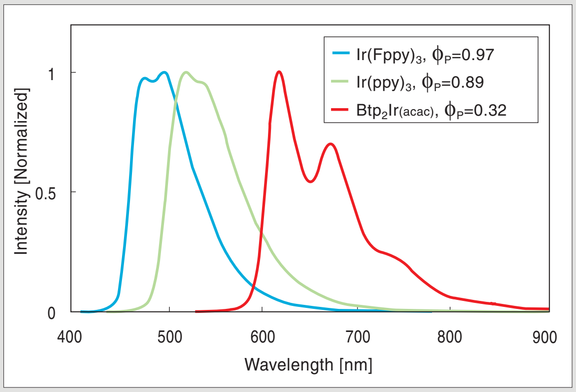
x-y coordinates

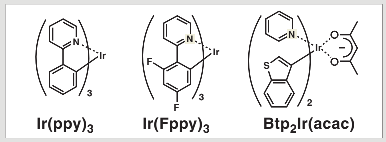


Besides displaying PL spectra and calculating quantum yields, the software also includes a function for color coordinates. Besides the chromaticity coordinates (x, y) of the measured sample, the three stimulus values (X, Y, Z) are displayed.

Our long and proven record in quantum yield measurements is the reason our products are favored by many users in a wide range of fields.

Phosphorescence quantum yield of phosphorescent materials for organic LED

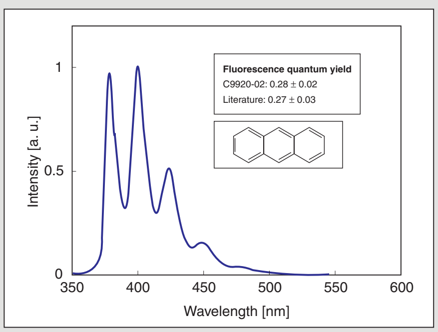




Iridium complex is the focal point of much recent research as a promising phosphorescent material for organic LEDs. We measured its phosphorescence quantum yield (ϕ_P) in diochloroethane solution. Results showed the blue material $Ir(Fppy)_3$ and green material $Ir(ppy)_3$ respectively indicate high ϕ_P values of approximately 0.97 and 0.89. The red material $Btp_2Ir(acac)$, on the other hand, yielded a low ϕ_P value of approximately 0.32. Since these phosphorescent materials form a triplet state with an efficiency of about 100%, the decrease in ϕ_P in $Btp_2Ir(acac)$ is clearly due to efficient intersystem crossing from T_1 to S_0 (in other words, a non-radiating transition from a triplet state T_1 to a ground state S_0).

Collaborative research of Hamamatsu Photonics K.K.; Adachi lab, CFC, Kyushu University; and Tobita lab, Faculty of Engineering, Gunma University.
A. Endo, K. Suzuki, T. Yoshihara, S. Tobita, M. Yahiro, and C. Adachi, *Chem. Phys. Lett.*, **460**,155 (2008).

Re-evaluation of luminescence quantum yield of representative standard solutions



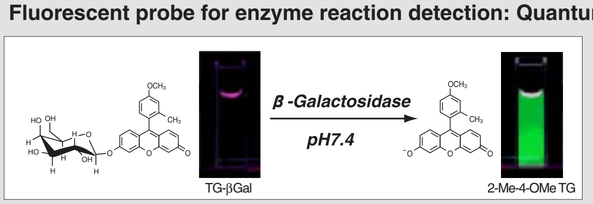
The C9920-0X (X=2,3) consists of an excitation light source, an integrating sphere and a multichannel spectrometer, and measures the absolute photoluminescence quantum yield. By using the C9920-0X, the quantum yields of fluorescence standard compounds in solution were measured. The compounds are commonly used as fluorescence standards in quantum yield measurements based on a relative method. For most of the compounds, the quantum yield measured by the C9920-0X shows excellent agreement with the values given in the literature, proving the high reliability of the C9920-0X.

Figure: Fluorescence spectrum and quantum yield of anthracene solution

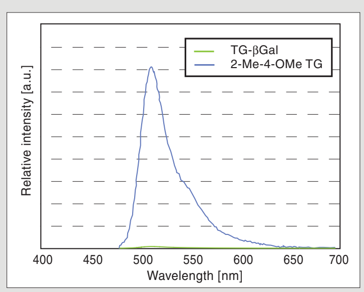
Collaborative research of Hamamatsu Photonics K.K.; A. Kobayashi, S. Kaneko, K. Takehira, T. Yoshihara, and S. Tobita, Faculty of Engineering, Gunma University; H.Ishida, Y.Shiina, and S.Oishi, School of Science, Kitasato University
K. Suzuki, A. Kobayashi, S. Kaneko, K. Takehira, T. Yoshihara, H. Ishida, Y. Shiina, S. Oishi, and S. Tobita, *Phys. Chem. Chem. Phys.*, **11**, 9850 (2009).

Quantum yield measurement of fluorescent bioprobe

Fluorescent probe for enzyme reaction detection: Quantum yield provides a comparative measurement.



Compounds	Fluorescence quantum yield
TG-βGal	0.01
2-Me-4-OMe TG	0.72



Fluorescent probe TG (Tokyo Green) -βGal for β-galactosidase activity detection is nonluminescent (ϕ_f= 0.01) but exhibits strong fluorescence after reacting with β-galactosidase. The quantitative difference in amounts of light emitted before and after the enzyme reaction can be found by comparing their quantum yields ϕ_f.

Courtesy of Yasuteru Urano, Ph.D., Graduate School of Medicine, the University of Tokyo.

Related products

We also offer a lineup of quantum yield measurement systems allowing diversified material evaluations on the same sample.

Fluorescence Lifetime and Absolute PL Quantum Yield

There are two processes when substances are excited by light irradiation from the ground state to excited singlet state (S1), then deactivated to the ground state again. One is radiative process such as fluorescence or phosphorescence, and the other one is a non-radiative process released as heat.

The fluorescence lifetime τ (tau) is defined as

$$k_f + k_{nr} = 1/\tau$$

where k_f is the radiative rate constant and k_{nr} is the non-radiative constant.

On the other hand, the PL Quantum Yield (ϕ) is expressed as the ratio of the number of photons emitted from molecules (PN_{em}) to that absorbed by molecules (PN_{abs}).

$$\phi = PN_{em} / PN_{abs}$$

However the PL Quantum Yield ϕ is also written as

$$\phi = k_f / (k_f + k_{nr})$$

Thus, there is a close relationship between τ (tau) and ϕ as shown in the following equation,
and they are very important parameters for controlling the emission mechanisms of the materials.

$$k_f = \phi / \tau$$

A diversified evaluation of the luminescence materials is now available!

Newly developed Quantaurus-Tau for measuring fluorescence lifetime and Quantaurus-QY for absolute PL quantum yield with simplified and minimized operating procedure are now available for everybody.
Combination of Quantaurus-Tau and Quantaurus-QY allow users to obtain complementary analysis results.

Compact Fluorescence Lifetime Spectrometer

Quantaurus-Tau®

Absolute PL Quantam Yieled Spectrometer

Quantaurus-QY®

Specifications

Type number	C11347-11 (Standard type)	C11347-12 (NIR type)
PL measurement wavelength range	300 nm to 950 nm	400 nm to 1100 nm
Monochromatic light source		
Light source	150 W xenon light source	
Excitation wavelength	250 nm to 850 nm	375 nm to 850 nm
Bandwidth	10 nm or less (FWHM)	
Excitation wavelength control	Automatic control	
Multichannel spectroscope		
Measurement wavelength range	200 nm to 950 nm	350 nm to 1100 nm
Wavelength resolution	<2 nm	<2.5 nm
Number of photosensitive device channels	1024 ch	
Device cooling temperature	-15 ˚C	
AD resolution	16 bit	
Spectroscope optical arrangement	Czerny-Turner type	
Integrating sphere		
Material	Spectralon	
Size	3.3 inch	
Software		
Measurement items	PL quantum yield	
	Excitation wavelength dependence of quantum yield	
	PL spectrum (peak wavelength, FWHM)	
	PL excitation spectrum	
	Color measurement (chromaticity, color temperature, color rendering index, etc.)	

Options

Sample holder

For solution

- **Dewar flask holder for low temperature measurement A11238-04**

For powder

- **Sample holder for temperature control A9924-17**
  This option allows setting the maximum temperature of powder samples up to 180 ˚C.
  Measurements can now be made in environments where phosphors for white LED are actually used.

Sample case

For solution

- **Side-arm cells (3 sets) A10095-02**

- **Sample tube for low temperature measurements A10095-04**
  This is used to measure a sample solution at liquid nitrogen temperature.

For powder

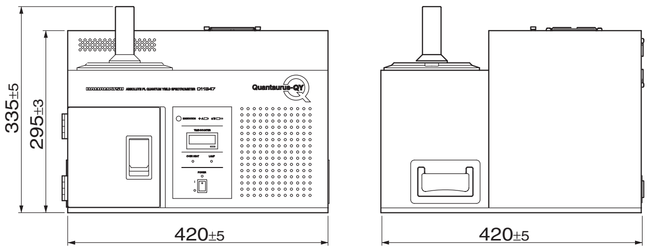
- **Laboratory dish A10095-01, -03 (with cover)**
  This is used for making measurements on thin-film and powder samples. This is a five-piece set made of synthetic quartz, which suppresses fluorescence and luminescence.

Others

- **Control unit A9924-17**
  The unit controls temperature of sample holder A9924-17.

Dimensional Outlines

(Unit: mm) weight: Approx.26.5 kg



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HAMAMATSU PHOTONICS K.K. www.hamamatsu.com

HAMAMATSU PHOTONICS K.K., Systems Division
812 Joko-cho, Higashi-ku, Hamamatsu City, 431-3196, Japan, Telephone: (81)53-431-0124, Fax: (81)53-435-1574, E-mail: export@sys.hpk.co.jp

U.S.A.: Hamamatsu Corporation: 360 Foothill Road, P. O. Box 6910, Bridgewater. N.J. 08807-0910, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218 E-mail: usa@hamamatsu.com
Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-2658 E-mail: info@hamamatsu.de
France: Hamamatsu Photonics France S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: infos@hamamatsu.fr
United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road Welwyn Garden City Hertfordshire AL7 1BW, United Kingdom, Telephone: 44-(0)1707-294888, Fax: 44(0)1707-325777 E-mail: info@hamamatsu.co.uk
North Europe: Hamamatsu Photonics Norden AB: Thorshamnsgatan 35 SE-164 40 Kista, Sweden, Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01 E-mail: info@hamamatsu.se
Italy: Hamamatsu Photonics Italia: S.R.L.: Strada della Moia, 1/E, 20020 Arese, (Milano), Italy, Telephone: (39)02-935 81 733, Fax: (39)02-935 81 741 E-mail: info@hamamatsu.it
China: Hamamatsu Photonics (China) Co., Ltd.: 1201 Tower B, Jiaming Center, 27 Dongsanhuan Road North, Chaoyang District, Beijing 100020, China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: hpc@hamamatsu.com.cn

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