Fluorescence lifetime spectrometer C16361 series

Quantaurus-Tau®

HAMAMATSU

PHOTON IS OUR BUSINESS

Quantaurus-Tau® is a compact system for measuring fluorescence lifetimes in the sub-nanosecond to millisecond range. Operation is simple, just set the sample into the sample chamber, and enter a few conditions on the measurement software to measure the fluorescence lifetime and PL spectrum in a short time with high precision.
In a typical measurement, analysis results are obtained in a mere 60 seconds.

Easy and quick measurements

Emission lifetime can be gotten easily and quickly only by putting the sample into sample box and setting the 4 measurement conditions.

7 excitation wavelengths

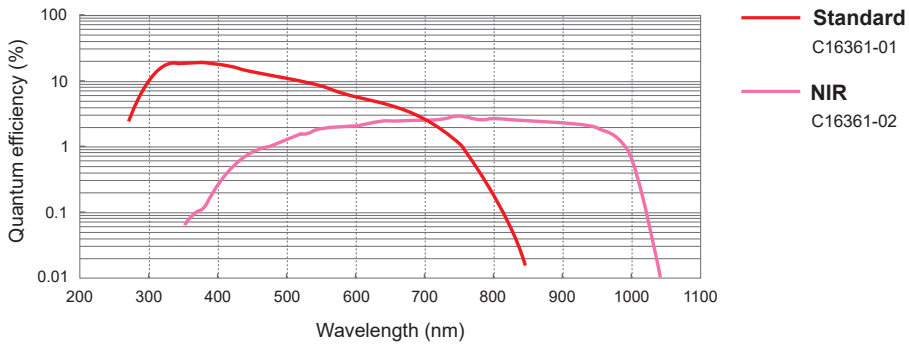
280 nm, 340 nm, 365 nm, 405 nm, 470 nm, 590 nm, and 630 nm.

Analyzing different sample forms

Thin-film, solid, solutions, and powder.

2 selections of detector

Detector spectral sensitivity



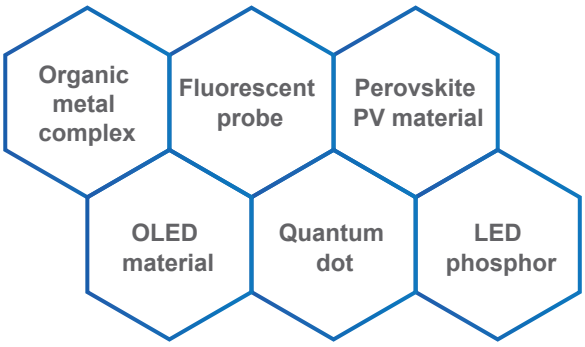
Capable of measuring various fluorescence lifetimes

The fluorescence spectrum obtained from an organic material or fluorescent probe is a vital parameter for controlling and evaluating the material functions and characteristics such as the peak wavelength and fluorescence intensity. However, a fluorescence spectrum usually shows time-integrated information, and so when the material contains multiple substances and reactive elements, their fluorescence spectrum can only be acquired as integrated information. An effective approach in such cases is to observe the light emission dynamics by making use of the time axis parameter. This is generally called fluorescence lifetime measurement, in which the time required for the substance excited by the pulsed light to return to its ground state is measured in the sub-nanosecond to millisecond region. This measurement allows obtaining more information such as multiple different fluorescence lifetimes even at the same wavelength and the percentage in which they are present within the material, etc.

Basic functions of fluorescence lifetime measurement

- **High sensitivity measurement by photon counting method (TCSPC*)**
  * Time correlated single photon counting
- **Time resolution better than 100 ps (by deconvolution)**
- **Cooling function for solution sample (-196 °C) (option)**
- **Phosphorescence measurement (option)**
- **Fluorescence spectrum measurement**

Application to fluorescence lifetime



Fluorescence lifetime measurement is applicable to varied applications. Typical applications include electron movement and energy transfer reactions within or between organic metallic complex molecules, as well as fluorescence and phosphorescence lifetime measurement of materials essential for developing organic EL devices, FRET (fluorescence resonance energy transfer) in fluorescent proteins, and pass/fail testing of compound semiconductors for solar cells and LED, etc.

The software takes account of the measurement procedure ensuring quick and easy measurements.

Set sample

Sample: solution / powder / solid / thin-film

Input

4 measurement conditions

① Excitation wavelength

② Emission wavelength

③ Time range

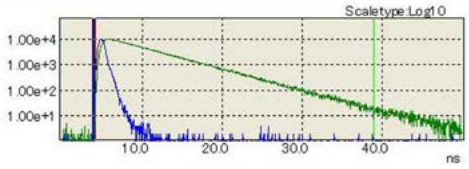
④ Stop conditions

Shifting delay, light intensity is automatically adjustable.

Start measurement

Set number of components

Measurement data

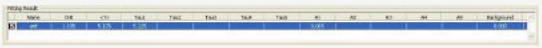


One-click analysis

deconvolution and fitting processes

In fluorescence lifetime measurements with a solution standard reagent - anthracene solution (QY=0.27), the analysis results are computed within **about 60 seconds*** after starting sample measurement

* If pre-measuring the IRF (Instrument Response Function)



Displays the analysis results as:

fluorescence lifetimes, component ratios, and chi-square test (χ^2)

- Multi-component processing up to five components
- Simultaneous multiple data comparison on the same screen
- Real-time display of time profiles and spectrum

Set parameter of multi-component processing

The range of the fitting data and IRF is specified for of each.

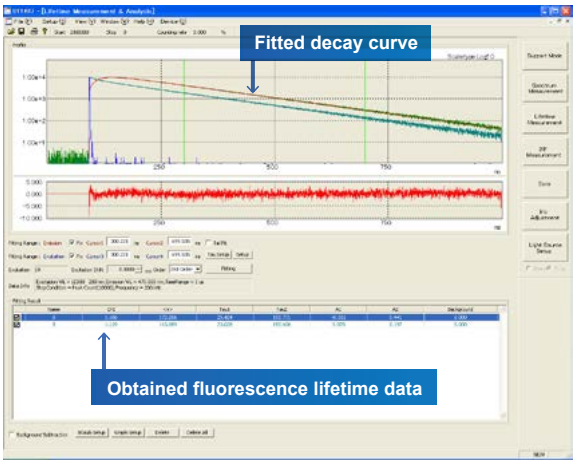
Set shift amount of IRF

Specimens can be analyzed manually

- Diversified analysis of lifetime components down to the order of sub-nano to milliseconds
- Rise time analysis
- Spectral analysis by monochromator control

Quantaurus-Tau® includes a variety of measurement and analysis functions such as simultaneous multi-component fluorescence lifetime measurement and multi-sample data comparison.

Multi-component fluorescence lifetime analysis and comparison



- **Multi-component analysis of up to five components**

  In fluorescence lifetime measurement, a phenomenon often occurs where the data is observed as the sum of the attenuation curves of multi-component fluorescence lifetimes. Quantaurus-Tau® easily calculates the fluorescence lifetime data and component ratio of each element by using the dedicated software.

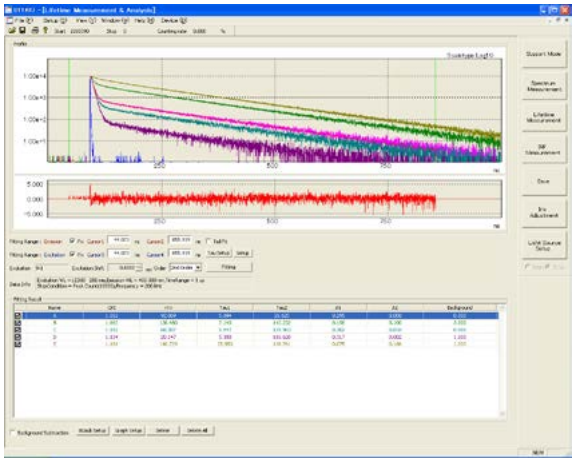
- **Highly accurate analysis by deconvolution**

  Deconvolution processing enables fluorescence lifetime analysis with high accuracy. When analyzing longer lifetime components such as phosphorescence, the "Tail Fit" function can be used instead of deconvolution processing.

- **Real-time display of time profiles and spectrum**

  Time profiles or spectrum are displayed on the monitor screen in real-time. This is a useful function for selecting the time scale during measurement or determining the analysis data range.

Multi-sample fluorescence lifetime analysis and comparison



- **Multiple data analysis on the same screen**

  Calculated fluorescence lifetime values are also displayed on the same screen for easy comparison analysis.

- **Comparisons under the same fitting conditions**

  To make comparison analysis under the same conditions, Quantaurus-Tau® subjects the multiple samples to specific fitting ranges, IRF (Instrument Response Function), and parameter settings.

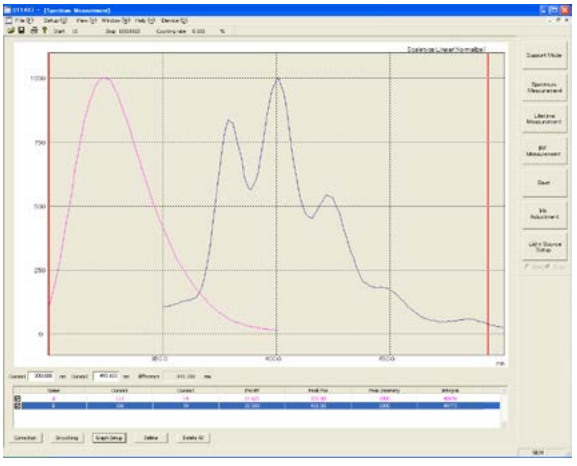
- **Graph editing with a graph setup feature**

  This allows you to change the range of each axis as needed on the comparison analysis screen so that the data can be edited to match your purpose. This feature also allows powerful normalizing whenever needed.

- **Acquired data can be easily stored as text data**

  The acquired data can be stored into the graph analysis software as text data by simple copy-and-paste operations.

Multi-sample PL spectrum analysis and comparison



- **Time-resolved spectrum display**

  Allows time-resolved spectrum display the greatest feature offered by streak camera systems.

- **Spectrum and fluorescence decay curve display**

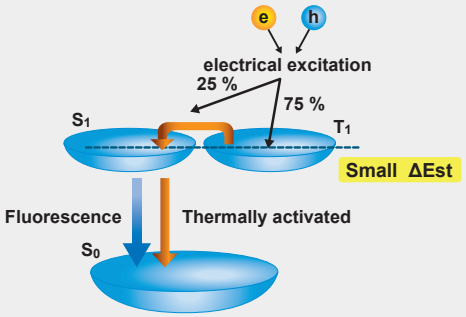
  Displays the full width at half maximum (FWHM), peak position and peak intensity for each profile.

- **Multiple data loading and comparison on the same screen**

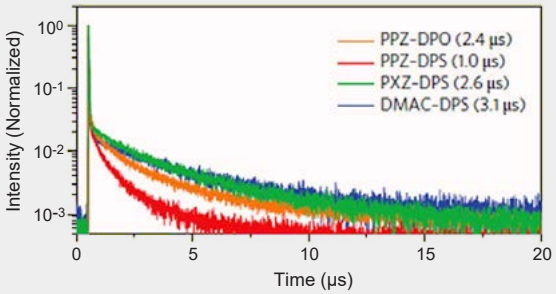
  Normalized processing makes multiple data comparison easy.

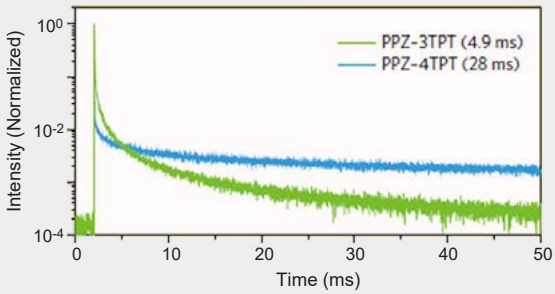
Our long and proven record in fluorescence lifetime measurements is the reason our products are favored by many users in a wide range of fields.

TADF of the blue OLED material

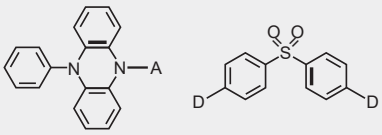


TADF (Thermally activated delayed fluorescence) is known well as the 3rd generation OLED material which is high efficiency and cost saving, furthermore can be replaced with phosphorescence material. The data shows the example of fluorescence lifetime measurement of blue TADF material. In order to achieve the high efficiency, the molecule design is the important factor to minimize the energy gap of excited singlet state (S_1) and excited triplet state (T_1).





Delayed fluorescence of TADF material results in that small gap of ΔEst, which is defined as the energy gap of S_1 state and T_1 state, is in the microsecond range. On the other hand, wide gap of ΔEst is in millisecond range.

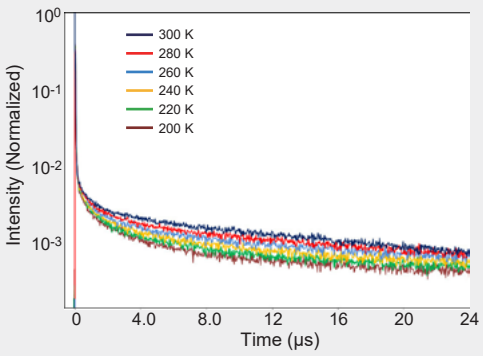


A= PPZ-DPO, PPZ-3TPT, PPT-4TPT D=PPZ-DPS, PXZ-DPS, DMAC-DPS	PPZ: 5-phenyl-5,10-dihydrophenazine DPO: 2,5-diphenyl-1,3,4-oxadiazole TPT: 3,4,5-triphenyl-1,2,4-triazole DPS: diphenylsulphone PXZ: phenoxazine DMAC: 9,9-dimethyl-9,10-dihydroacridine

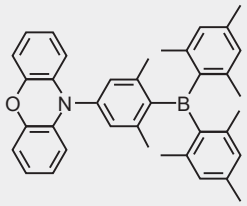
Data courtesy of Prof. Chihaya Adachi, Hajime Nakanotani
Center for Organic Photonics and Electronics Research, Kyushu Univ.

Q. Zhang, B. Li, S. Huang, H. Nomura, H. Tanaka and C. Adachi, *nature photonics.* **8**, 326 (2014)

Temperature dependency of fluorescence lifetime with TADF material



Temperature dependence of transient PL decays of triarylboron-based OLED emitter doped in CBP (16 wt%).



The fluorescence lifetime measurement example to observe the temperature dependency of triarylboron-based compound which is the TADF material. Phosphorescence material as the typical OLED material has chemical behavior to decrease the ratio of the light components by the temperature increasing. As the temperature rose, TADF material, however, increased the delayed fluorescence components and resulted the delay components were activated by the heat. The temperature dependency measurement was done with the setup of Cryostat.

Data courtesy of Prof. Hironori Kaji, Atsushi Wakamiya, Katsuaki Suzuki, Institute for Chemical Research, Kyoto Univ.
Data courtesy of Prof. Chihaya Adachi, Center for Organic Photonics and Electronics Research, Kyushu Univ.

K. Suzuki, S. Kubo, K. Shizu, T. Fukushima, A. Wakamiya, Y. Murata, C. Adachi, H. Kaji, *Angew chem. Int. Ed.* **54**, 15231 (2015).

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 the excited state (S_1), then deactivated to the ground state again. One is radiative process such as fluorescence and the other 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}).

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

The PL Quantum Yield Φ is also written as

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

Thus, there is a correlation 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.

$$k_f = \Phi / \tau$$

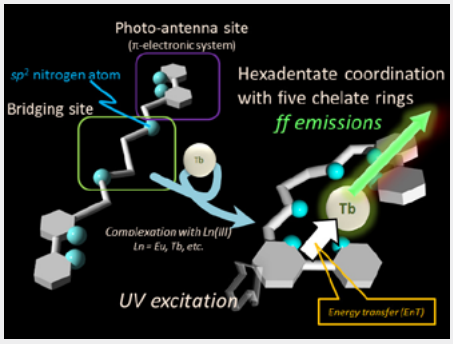
Fluorescence lifetime spectrometer
C16361 series

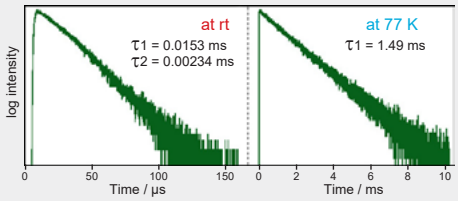
Absolute PL quantum yield spectrometer
C11347 series

A diversified evaluation of the luminescence materials is available!

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

ff luminescent characteristic of Lanthanide complex





Luminescence lifetime of Lanthanide complex

Lanthanide compound has a characteristic of high luminescent performance and is expected to apply for the variety of functional materials such as OLED, photovoltaic or a sensor.
The fluorescence lifetime of a series of Lanthanide complex was measured in the acetonitrile solution (at room temperature) and the solid state (at room temperature, at 77 K). A series of Lanthanide complex has Bipyridine skeleton.
The remarkable difference was observed to fluorescence lifetime depending on the temperature (τ) and Quantum yield (QY) of Tb^{III} complex which has the characteristic of thermal equilibrium caused by the energy transfer between excited triplet state of ligand and the energy level of center metal.

		Temp.	τ [ms](amp.)	QY[a] [%]
EuL	In the solid state	rt	1.27 (1.0)	52.6 (±1.4)
		77 K	1.35 (1.0)	63.5 (±2.7)
	In acetonitrile	rt	1.55 (1.0)	12.0 (±0.5)
TbL	In the solid state	rt	0.0153 (0.96) 0.00234 (0.04)	1.0 (±0.2)
		77 K	1.49 (1.0)	91.5 (±1.4)
	In acetonitrile	rt	n.d.	≈ 0

[a] The values of Ln emission were based on the ligand excitation, and observed with Absolute PL quantum yield spectrometer C9920-02.

Data courtesy of Prof. Miki Hasegawa, Aoyama Gakuin Univ.

M. Hasegawa, H. Ohtsu, D. Kodama, T. Kasai, S. Sakurai, A. Ishii, and K. Suzuki, *New J. Chem.*, **38**, 1225 (2014)

L: Ligand
amp.: amplitude
rt: room temperature

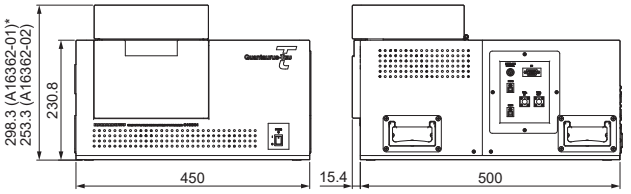
Specifications

Type number	C16361-01	C16361-02
Detector type	Standard	NIR
Wavelength range	300 nm to 800 nm	380 nm to 1030 nm
Excitation light source	Seven types of LED light source (280 nm, 340 nm, 365 nm, 405 nm, 470 nm, 590 nm, 630 nm)	
Excitation light source switching	Software control	
Monochromator	Czerny-Turner monochromator	
Measurement time range	4 ns to 10 s / full scale	
Time range for phosphorescence measurement	200 µs to 10 s / full scale (option)	
Phosphorescence measurement	Phosphorescence excitation wavelength (280 nm, 340 nm, 365 nm, 405 nm, 442 nm, 470 nm, 589 nm, 632 nm, 1000nm)	
Time axis channel	512 ch, 1024 ch, 2048 ch, 4096 ch	
Total time resolution	< 1.0 ns FWHM (IRF with 590 nm LED)	
Analysis function	Fluorescence lifetime analysis (up to five components by exponential function fitting) and spectrum analysis	
Supported OS	Windows® 11 Pro	

Options

	Type number	Product name	
Sample box	A16362-01	Sample box for solution sample	A16362-01 is a sample box for measuring the solution samples (compatible with 10 mm square cells) or thin film samples.
	A16362-02	Sample box for solid sample	A16362-02 is a sample box for measuring the powder samples or thin solid film samples.
	A11797-02	Sample box for Low-temperature	A11797-02 is a sample box for setting A11238-04 when measuring the lifetime of a solution samples at liquid nitrogen temperature.
	A12268-01	Sample box for cryostat Optistat DN	Sample box for Optistat DN2 (Oxford Instruments).
Sample holder	A11238-04	Sample holder for low temperature	This is used to cool the solution sample with liquid nitrogen. This can be shared with Quantaurus-QY®.
	A11238-05		This is used to cool the solution sample with liquid nitrogen. This can be shared with Quantaurus-QY® Plus.
Sample case (For solution)	A10095-02	Side-arm cell (3 pieces)	This is used to measure a sample solution at liquid nitrogen temperature.
	A10095-04	Sample tube for low temperature measurement (5 pieces)	
Sample case (For powder)	A10095-01	Laboratory dish without caps (5 pieces)	This is used for making measurements on powder samples. This contains 5 dishes made of synthetic quartz, which suppresses fluorescence and luminescence.
	A10095-03	Laboratory dish with caps (5 pieces)	
	A13712	Tweezers for A10095-03	Tweezers for grasping petri dishes.
Light source	C11567-02	Xenon flash lamp unit For Phosphorescence measurement	C11567-02 is the excitation light source using Xenon flash lamp for phosphorescence measurement from a few tens of microseconds to milliseconds.
	A12991-280	Band pass filter (280 nm)	Band pass filter for the wavelength 280 nm.
	A13905-XXX	Band pass filter	Selectable from among the following wavelengths: 340 nm, 365 nm, 405 nm, 442 nm, 470 nm, 589 nm, 632 nm, 1000 nm.
	M12488 series	PLP-10-XXXTAU Laser diode head	M12488 series are the dedicated laser diode heads for Quantaurus-Tau®, which can be used in combination with the controller and adapter. Selectable from the following wavelength of 375 nm, 405 nm, 445 nm, 465 nm, 483 nm, 510 nm, 655 nm, 785 nm, 850 nm.
	A12487-01	Adapter	A12487-01 is an adapter for attaching M12488 to Quantaurus-Tau®. A12487-01 is used when excitation light source is the PLP-10.

Dimensional outlines (unit: mm) Weight: 31 kg



* The height is changed by sample box type.

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- The university, institute, or company name of the researchers, whose measurement data is published in this brochure, is subject to change.
- The spectral response specified in this brochure is typical value and not guaranteed.
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- Specifications and external appearance are subject to change without notice.

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