C101-E174

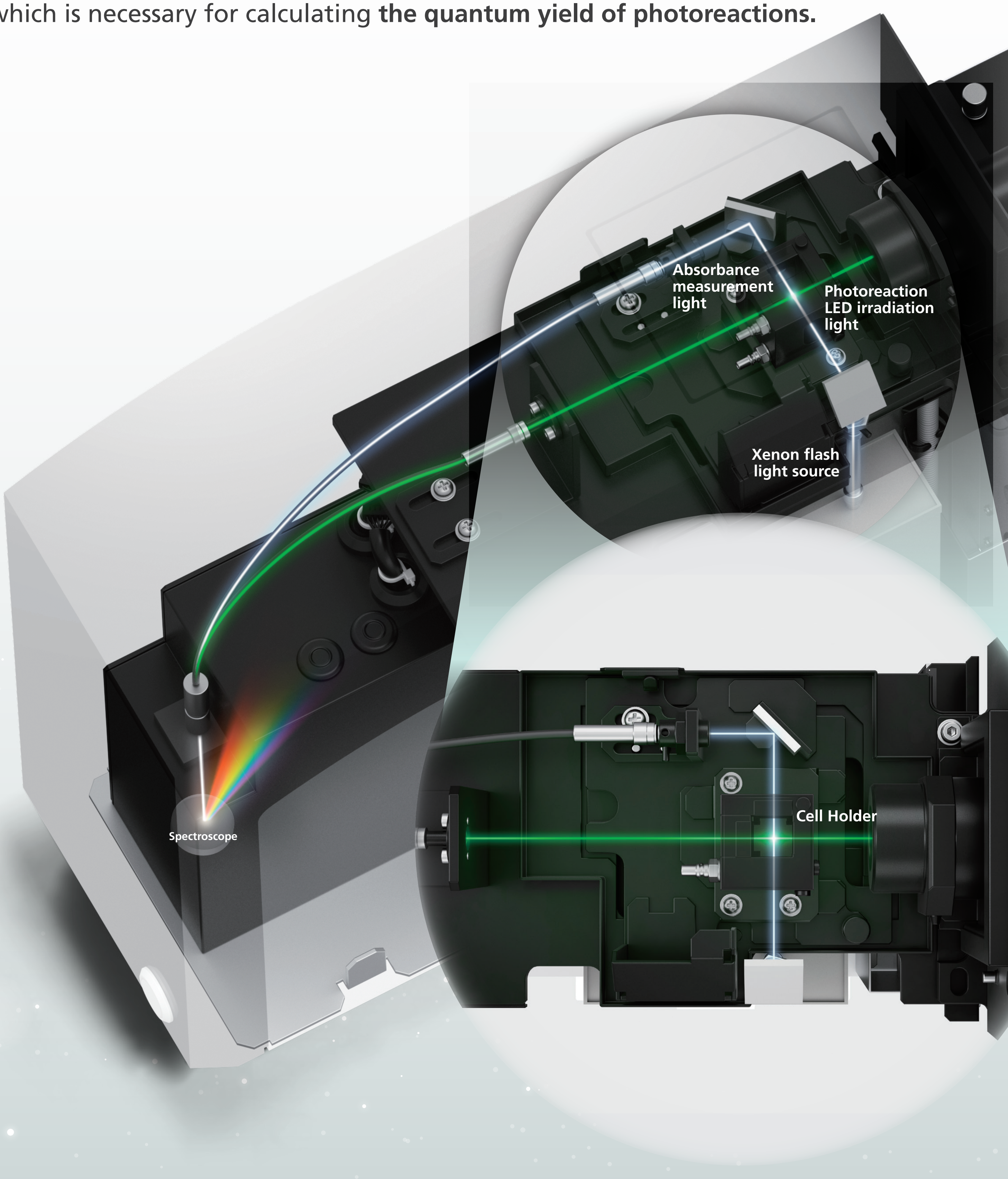
SHIMADZU
Excellence in Science

PQY-01 Photoreaction Evaluation System

Lightway

Lighting the Way to

This system can measure **the number of photons absorbed,** which is necessary for calculating **the quantum yield of photoreactions.**



the Future

ANALYTICAL INTELLIGENCE

Shortens Experimental Process

Functionality for calibrating the number of photoreaction photons eliminates the need for chemical actinometers.

Measuring is Easy

The all-in-one Lightway includes a software function that guides the necessary operating steps to the user and all the elements required for monitoring photoreaction processes in real time, which makes it easy to measure photons.

Measures Photon Count Accurately

Eliminates individual differences resulting from how chemical actinometers are made. Using an LED irradiation light source* ensures consistent measurements for many hours.

ANALYTICAL INTELLIGENCE

Analytical Intelligence is a new concept for analytical instruments offered by Shimadzu Corporation. It consists of systems and software that simulate expert operators automatically determining whether or not conditions and results are good or bad, providing feedback to users, and solving common problems. It increases data reliability by compensating for any differences between users in their instrument knowledge or experience.

* This product is manufactured by CELL System Co., Ltd. Therefore, it must be purchased separately.

This photoreaction evaluation system was developed by Shimadzu Corporation, under the supervision of Professor Osamu Ishitani and Associate Professor Yusuke Tamaki of the Department of Chemistry, Graduate School of Science and Engineering, Tokyo Institute of Technology.

Shortening Experimental Process

Conventional measurement requires a lengthy process using a chemical actinometer but Lightway™ includes functionality that calibrates the number of irradiated photons, eliminating this process.

*Using a chemical actinometer involves sample adjustment process steps, such as crystallizing, air drying, and diluting samples, and then measuring the number of photons in a dark room and calibrating the number of photons irradiated on the sample.

About 6 hours ＋ About 1 hour ＋ About 5 hours ＝ Total of about 12 hours

Conventional Method*

Adjust chemical actinometer → Irradiate light onto sample and measure the change in absorbance. → Calculate number of photons absorbed by sample.

Use chemical actinometer to calculate number of irradiated photons.

Lightway

About 10 minutes

Irradiate reaction light onto sample and automatically calculate the number of photons absorbed.

* Conventional method requires a chemical actinometer.

Photoreaction Quantum Yield:

$$\text{Photoreaction quantum yield} = \frac{\text{Number of molecules generated}}{\text{Number of Photons absorbed}^*}$$

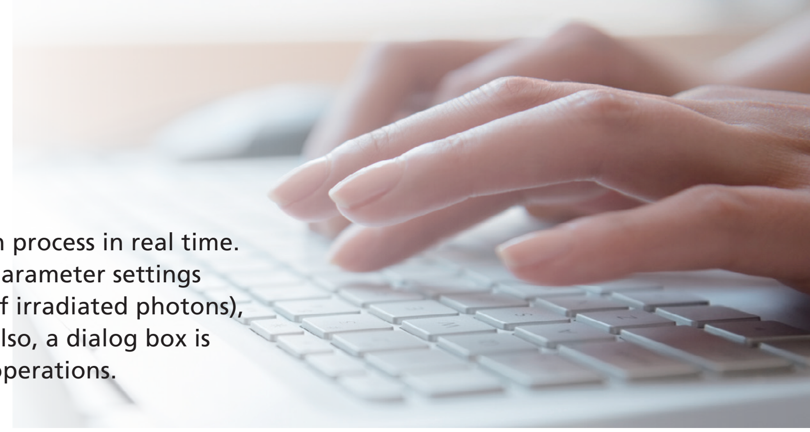
Important indicator of photoreaction efficiency for photocatalysts, etc.

A gas chromatograph (GC) is used to measure the number of gas molecules generated and a liquid chromatograph (LC) to measure number of liquid molecules.

Lightway accurately determines the number of photons absorbed by the sample, based on the number of photons irradiated and the absorption spectrum.

For a comparison to data obtained with the conventional method using a chemical actinometer, refer to LAAN-A-UV-E041 Application News bulletin No. A478.
Application News bulletins are available from the Shimadzu website.

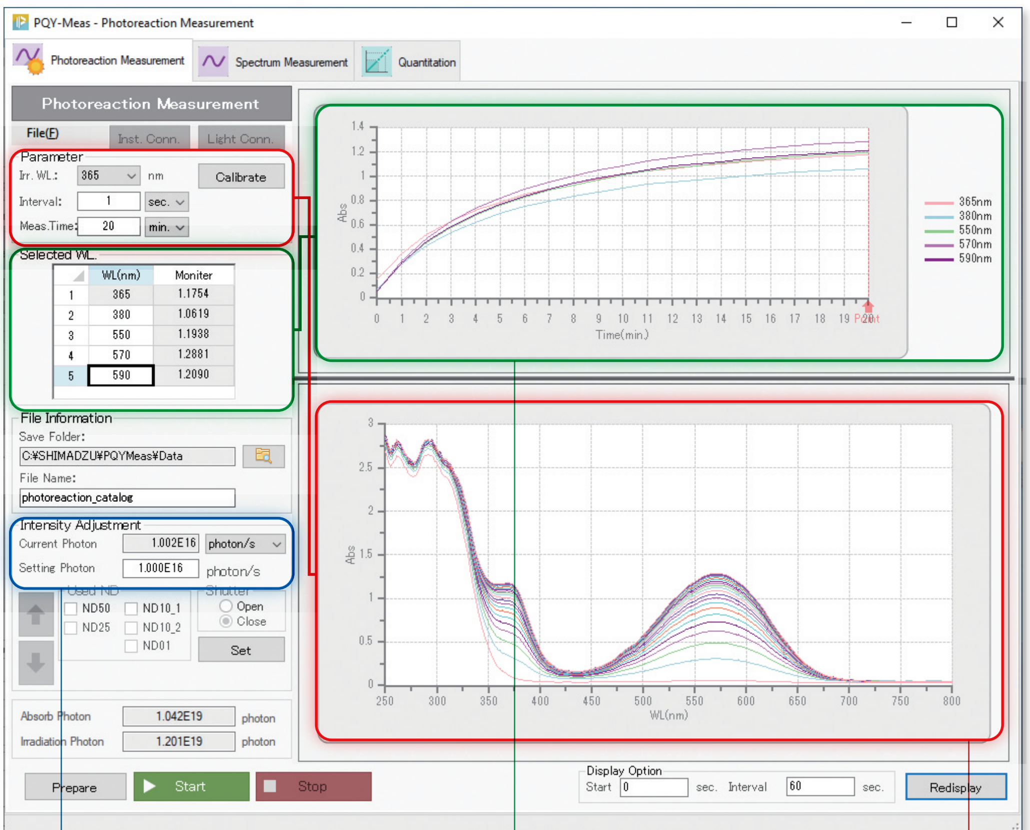
* The values may not be correct if the sample has scattering properties or is absorbed by the solvent.



Easy Measurement

It can monitor spectral changes* during the photoreaction process in real time. Measurements can be started by specifying mainly three parameter settings (measurement interval, measurement time, and number of irradiated photons), which makes it easy to operate even for first-time users. Also, a dialog box is displayed whenever a button is pressed to help navigate operations.

* Results for specific wavelengths can be graphed as a function of time.



Irradiated light settings	Time-course measurement results at a monitored wavelength	Measurement results for all spectra
LEDs provide stable, bright, and long-lasting irradiation light. That means reliable results can be obtained anytime. Also, experimental reproducibility can be increased by specifying the quantity of light irradiated.	**Time-course changes in the absorbance at any particular wavelength can be determined instantaneously.** By specifying the specific wavelength as the monitored wavelength before starting a measurement, spectral changes can be displayed as a function of time, so that the end of the reaction can be confirmed more quickly and the reaction rate can be confirmed more intuitively.	**No bothersome settings are necessary.** Only the measurement interval and measurement time need to be specified for spectra measurement conditions. The minimum measurement interval setting is 0.1 seconds. That means spectra from 250 to 800 nm can be acquired within 0.1 seconds to track reactions quickly.

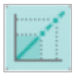
The PQY-™ Meas software that comes standard with the system offers the following three modes.

Photoreaction Measurements

Measures a spectrum while the sample is irradiated by the irradiation light source.

Spectral Measurements

Measures a spectrum after the sample is irradiated by the irradiation light source. It can also perform regular spectral measurements as a spectrophotometer.



Calibration Curve & Quantitation

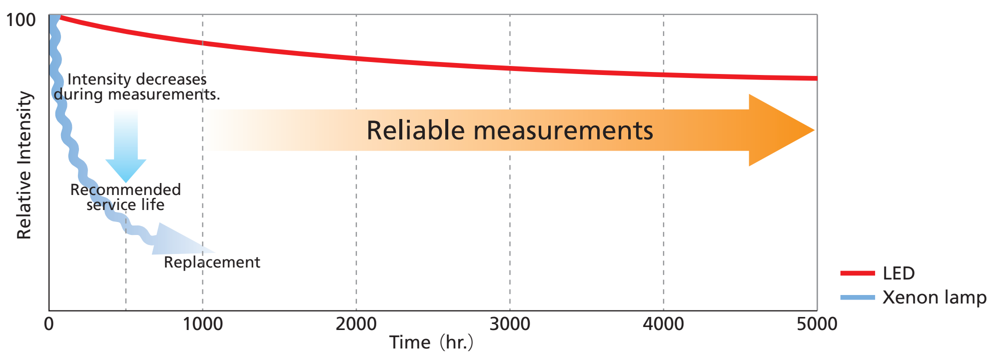
Creates a calibration curve from a standard sample to determine concentrations in unknown samples.

Measuring Photon Count Accurately

Previously, a chemical actinometer was required to calculate the number of irradiated photons, but there were concerns about variability caused by the chemical actinometer adjustment process. The Lightway™ system uses a power meter to calibrate the number of irradiated photons and make corrections based on spectral shape prior to measuring, which prevents variability caused by differences in skill levels.

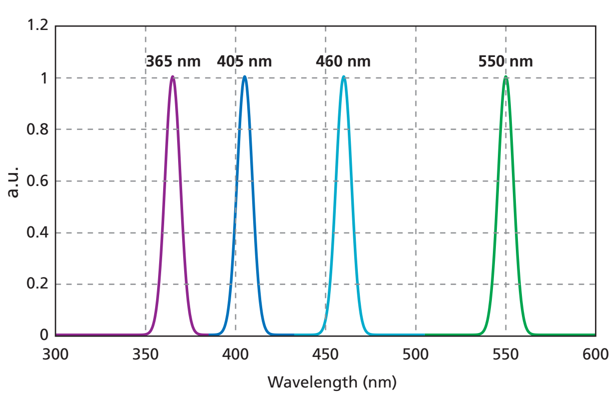
It also features a stable and long-lasting LED irradiation light source.

Using an LED irradiation light source means reliable measurements can be obtained over long periods.



The figure above illustrates one example of how light source intensity decreases over time. The red line indicates the intensity of an LED irradiation light source, whereas the blue line indicates the intensity of a xenon lamp irradiation light source. It shows that the LED irradiation light source offers high intensity for a longer time and the intensity decrease is more gradual than for the xenon lamp irradiation light source.

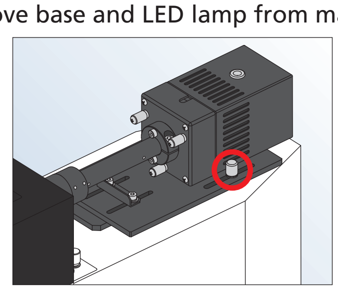
An optional LED irradiation light source is available.*

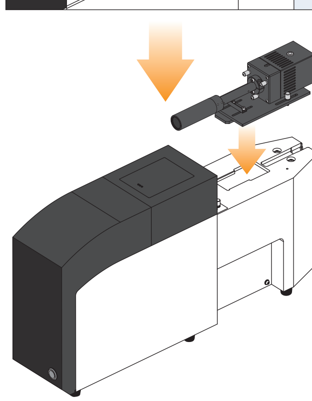


* This product is manufactured by CELL System Co., Ltd. Therefore, it must be purchased as an optional product.

The LED irradiation light source can be replaced easily.

Remove base and LED lamp from main unit.





Install new LED lamp with base into the main unit.

Applications

Various applications using the system are described below.
(Measured by: Associate Professor Yusuke Tamaki of the Department of Chemistry, Graduate School of Science and Engineering, Tokyo Institute of Technology)

Using a Ru-Re Supramolecular Complex Photocatalyst to Measure Photoreaction Quantum Yield of CO_2 Reduction Reaction

●Measuring Photoreaction Quantum Yield

A Ru-Re supramolecular complex photocatalyst (Fig. 1) was used to measure the quantum yield of a carbon dioxide reduction reaction. The sample was irradiated with 17 × 10^{-9} einstein·s^{-1} of 470 nm light and then the absorption spectrum and number of photons absorbed were measured. Carbon monoxide generated from the reduction reaction was then quantified using a gas chromatograph. The graph in Fig. 2 correlating the quantity of carbon monoxide generated to the number of photons absorbed was obtained. Since the reaction quantum yield corresponds to the slope in Fig. 2, a result of 40 % was obtained for the given experiment.

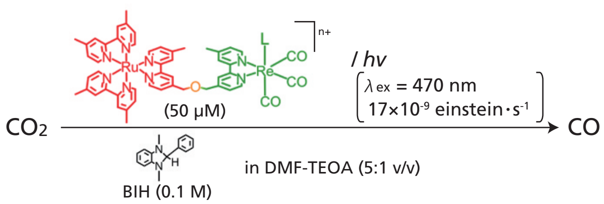


Fig. 1 Diagram of Ru-Re Supramolecular Complex Photocatalyst Reaction

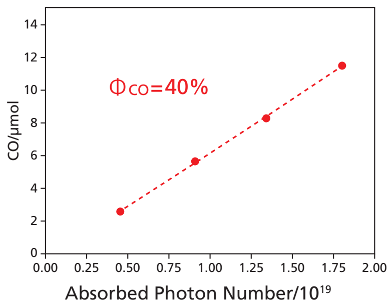


Fig. 2 Quantity of Carbon Monoxide Generated vs. Number of Photons Absorbed

●Measuring Intermediates

An attempt was made to directly observe intermediates during the carbon dioxide photoreduction reaction of a Ru-Re supramolecular complex photocatalyst (Fig. 1). Time-course changes in absorption spectra measured during the photocatalytic reaction are shown in Fig. 3. Difference spectra with respect to the absorption spectrum measured at the start of measurement are shown in Fig. 4. The new absorption observed near 550 nm in Fig. 3 and Fig. 4 is due to the absorption spectra of intermediates. A comparison to previously reported data confirmed that the intermediates are one-electron reduced species from a photoelectron-transfer reaction of the Ru-Re supramolecular complex photocatalyst.

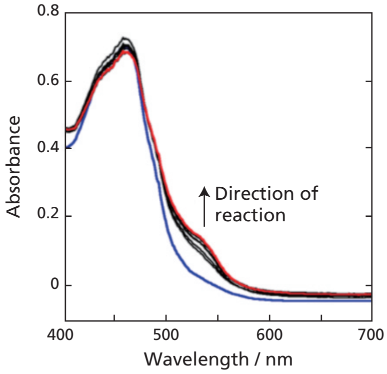


Fig. 3 Ru-Re Supramolecular Complex Photocatalyst Reaction Spectral Measurement Results

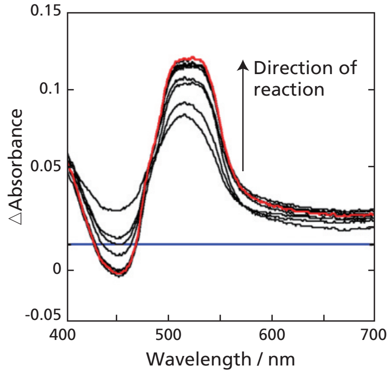


Fig. 4 Ru-Re Supramolecular Complex Photocatalyst Reaction Difference Spectra Calculation Results

Accessories

Description	P/N	Remarks
LED Adapter	207-26440-41	Adapter used to install the LED irradiation light source in the main Lightway unit. Includes one LED mount.
LED Mount	207-25324-45	This part is used to attach the LED irradiation light source to the LED adapter. Provide one mount for each LED irradiation light source.
LED Irradiation Light Source*	Iris-S	An LED irradiation light source is recommended. LED irradiation light sources are available for 365 nm, 405 nm, 460 nm, 550 nm, and other wavelengths. Additional units can be purchased as necessary.
LED Controller*	IRS-1000	Controller for the LED irradiation light source. One controller is required per system.
Temperature-Control Tubing Set	207-26433-41	Samples can be temperature-controlled by pumping temperature-controlled water through this tubing. The tubing temperature range is 15 to 60 °C. • Temperature-controlled water is required separately.

* These products are manufactured by CELL System Co., Ltd. To purchase them, contact a Shimadzu sales representative or distributor.

Shimadzu Corporation

www.shimadzu.com/an/

First Edition: May 2020 3655-03010-PDFIT