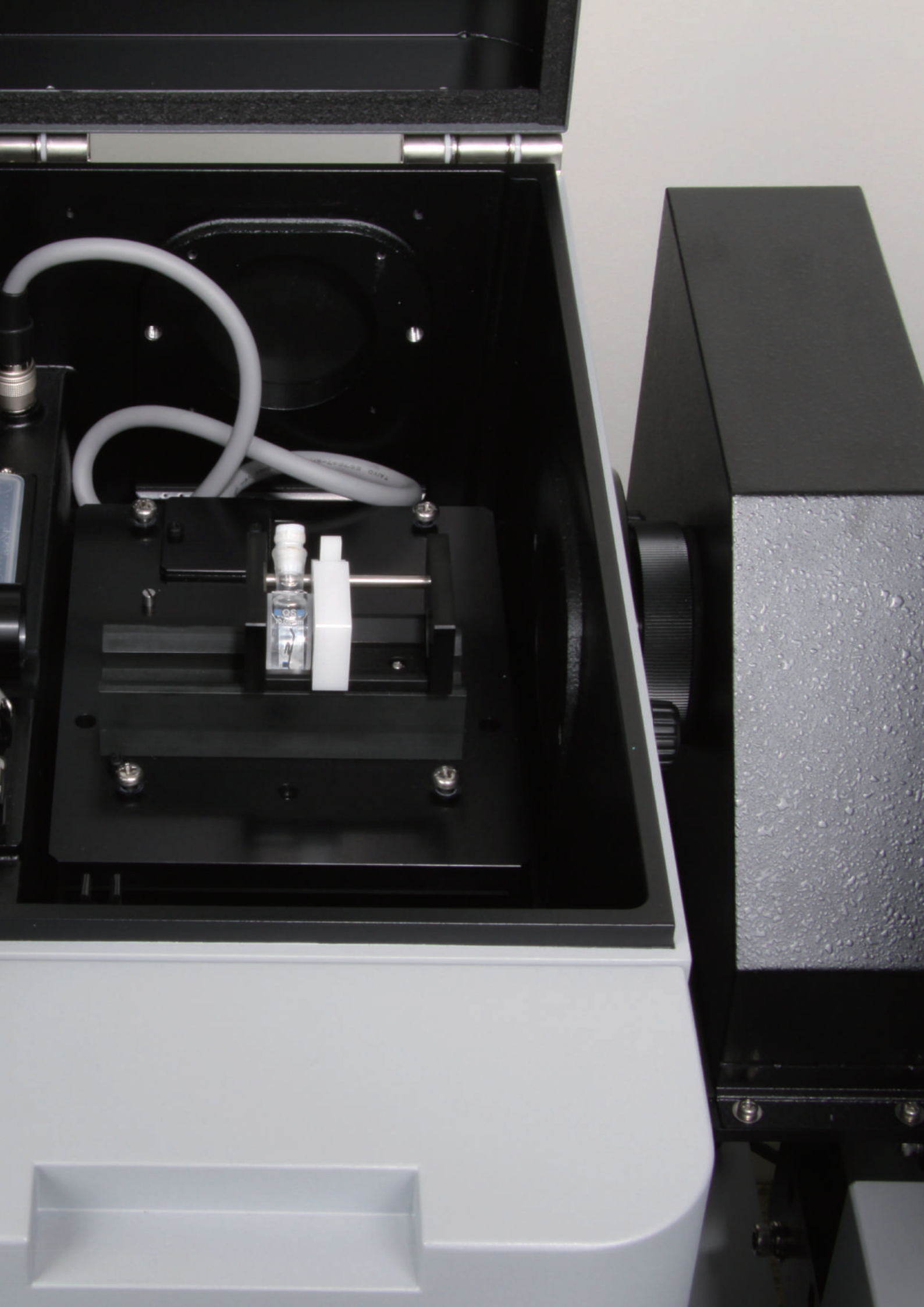
Circularly Polarized Luminescence Spectrometer

CPL-300

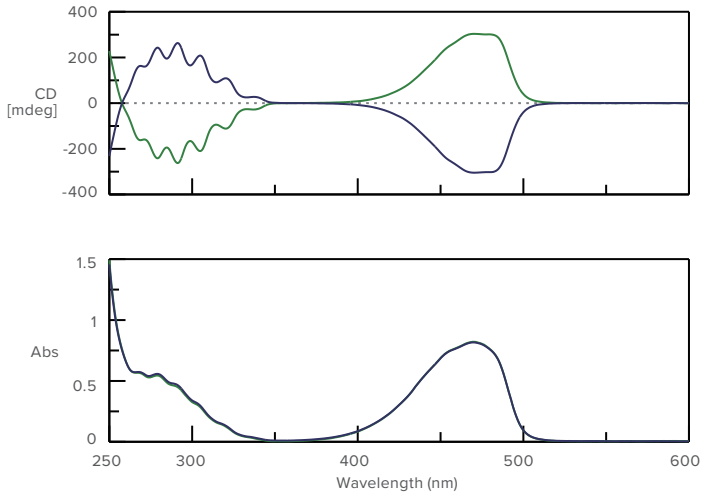
JASCO

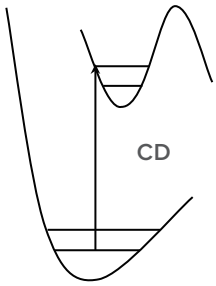
Performance
Innovation
Reliability



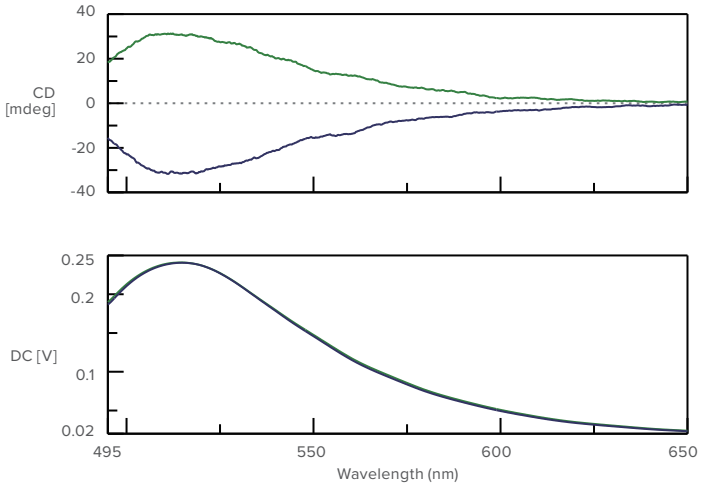
JASCO CPL spectroscopy

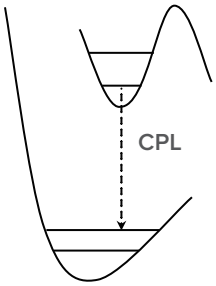
Circularly polarized luminescence (CPL) offers complementary information to other chiroptical techniques such as Optical Rotatory Dispersion (ORD), Circular Dichroism (CD), Vibrational Circular Dichroism (VCD) and Raman Optical Activity (ROA). A CPL signal is the intensity difference between left and right circularly polarized light emitted by a chiral molecule which is excited with unpolarized light.





CD (top) and absorbance (bottom) spectra of camphorquinone (measured by the JASCO J-1500 CD)





CPL (top) and fluorescence (bottom) spectra of camphorquinone (measured by CPL-300)

Recently, CPL spectroscopy is employed as an analytical technique for molecules which emit circularly polarized light such as those used in 3D display manufacturing and other novel technologies. Historically, the CPL technique was used mainly with liquid samples. The new JASCO CPL-300 allows the use of not only liquid but solid sample measurements, including temperature control and magnetic field measurements.

CPL-300 CPL spectrometer

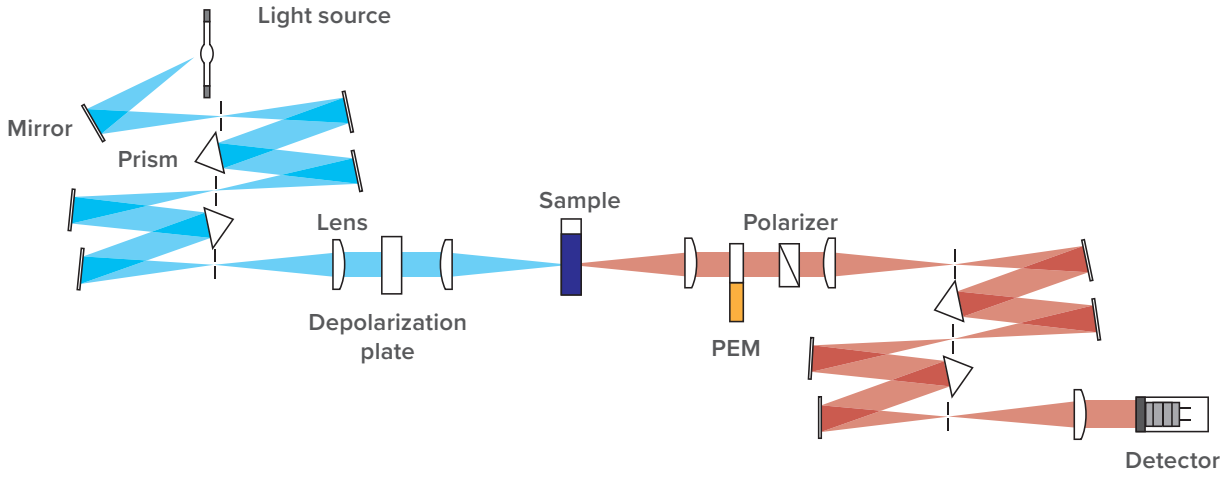
JASCO's uniquely designed CPL-300 allows detection of a very weak CPL signal with an unparalleled degree of reliability and ease of use. The CPL-300 is designed with two monochromators: an excitation monochromator generates monochromatic depolarized light which excites a chiral sample and an emission monochromator collects the fluorescence light emitted by the sample. A unique piezoelastic modulator and ultra-sensitive photomultiplier tube allow detection of the CPL signal.

High quality 180° optical system

A 180° optical system with unpolarized excitation light reduces artifacts generated by fluorescence anisotropy allowing the sample's core properties to be determined.

Double-prism monochromator

Many CPL signals are inherently weak. As such, it is imperative to employ a very low stray light optical system in order to resolve and detect a signal. The CPL-300's optical system employs a double monochromator design with quartz prisms eliminating high-order radiation resulting in excellent detection of weak signals.



Optical diagram of CPL-300

Circular polarization modulation and lock-in detection

The CPL-300 is based on a circular polarization modulation and lock-in amplification system which enables detection of extremely small intensity differences between left and right circularly polarized emitted light – often in the presence of signal noise.

Data collection and processing

The CPL-300 simultaneously collects two sets of data while keeping the photomultiplier tube at a constant gain.

- **The CPL signal is measured as a demodulated AC component in millidegrees of elipticity**
- **The Fluorescence intensity (*I*) is measured as a DC signal in volts**

Both data sets can be converted to the luminescence dissimetry factor (g_{lum}).

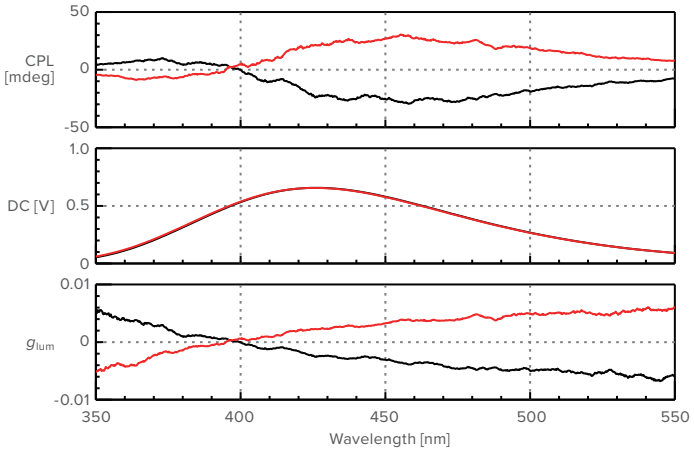
Measurement of solid-state samples

Chiral properties of molecules in both liquid and solid states can differ greatly. Many of the devices used in today's advanced technological fields of research are based on circularly polarized light-emitting molecules. CPL is an ideal technique for use with these solid-state samples.
The CPL-300's unique 180° linear optical design provides pure, unpolarized excitation light allowing the elimination of artifacts due to fluorescence anisotropy[1]. Samples such as KBr pellets and PMMA films are easily measured providing highly reliable CPL spectra[2, 3, 4]. CPL measurements on samples with known macroscopic anisotropy such as single crystals are routinely reported in literature using a dedicated CPL spectrometer[5]. In addition, measurements on solid-state samples are being reported today using the JASCO CPL-300 Spectrometer[6].

Measurement of liquid samples

CPL spectra of camphor/EtOH solution are shown below.

Measurement time:
~24 min.
(time of one scan ~4 min.)
Data interval: **0.2 nm**



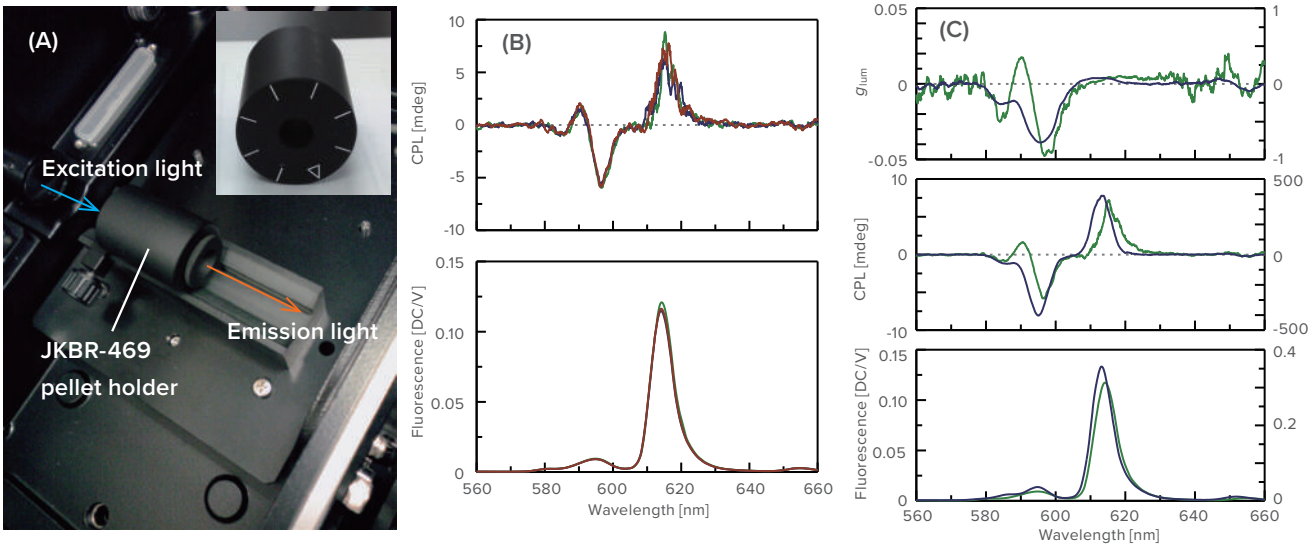
CPL spectra of camphor/EtOH solution (No data smoothing)

(1) P. M. L. Blok, H. P. J. M. Dekkers: *Appl. Spectrosc.*, **44** (2), 305 (1990)
(2) T. Kimoto, T. Amako, N. Tajima, R. Kuroda, M. Fujiki, Y. Imai: *Asian J. Org. Chem.*, **2**, 404 (2013)
(3) K. Nakabayashi, T. Amako, N. Tajima, M. Fujiki, Y. Imai: *Chem. Commun.*, **50,** 13228 (2014)
(4) A. Taniguchi, D. Kaji, N. Hara, R. Murata, S. Akiyama, T. Harada, A. Sudo, H. Nishikawa, Y. Imai: *RSC Adv.*, **9**, 1976 (2019)
(5) T. Harada, R. Kuroda, H. Moriyama: *Chem. Phys. Lett.*, **530**, 126 (2012)
(6) Y. Kondo, S. Suzuki, M. Watanabe, A. Kaneta, P. Albertini, K. Nagamori, K: *Front. Chem.*, **8**, Article 527, 1 (2020)

Applications for CPL

Solid-state sample holder

JASCO provides as standard a dedicated sample holder for KBr pellets and film samples. In addition, custom holders can be designed for various sample sizes[6].

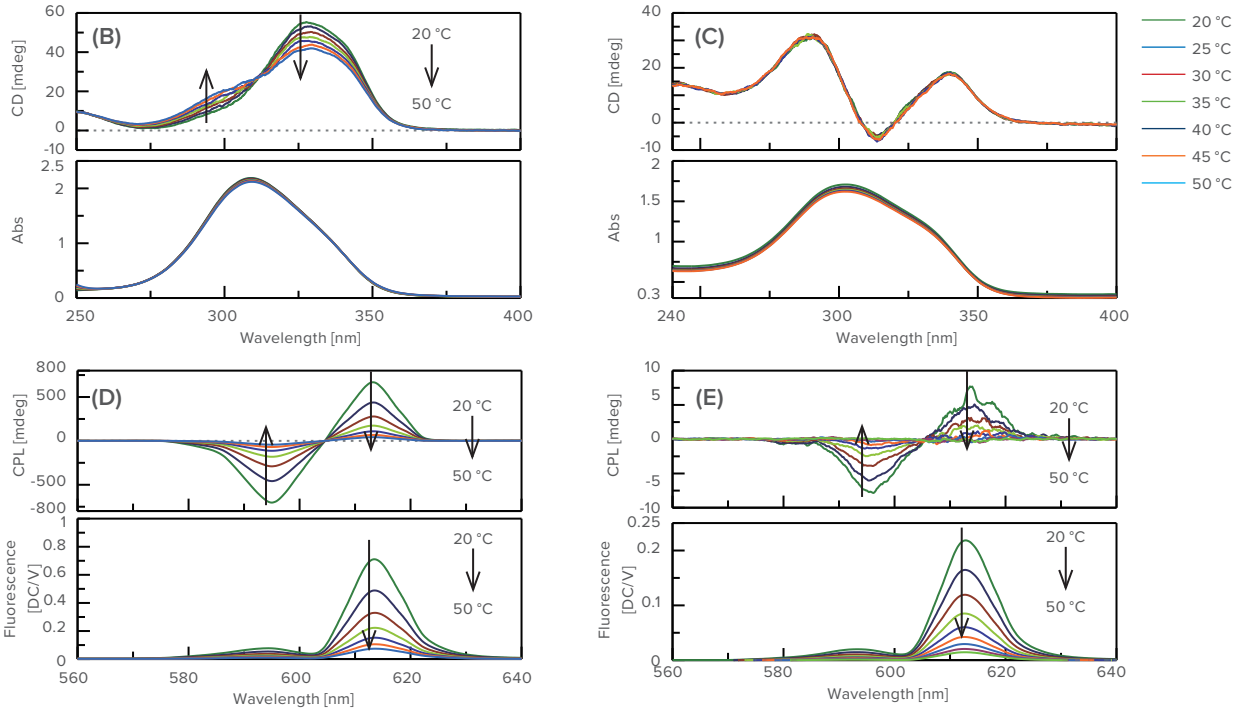


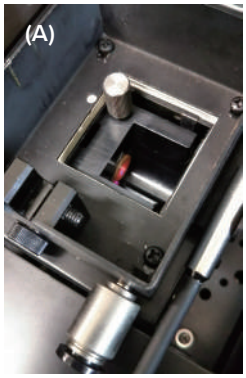
(A) CPL-300 sample compartment using the JKBR-469 pellet holder. (B) CPL and fluorescence spectra of $Eu(facam)_3$/KBr pellet at rotation angles of 0° (green), 45° (blue) and 90° (red). (C) g_{lum}, CPL and fluorescence spectra of $Eu(facam)_3$/KBr pellet (green, left vertical axis) and in DMSO solution (blue, right vertical axis).

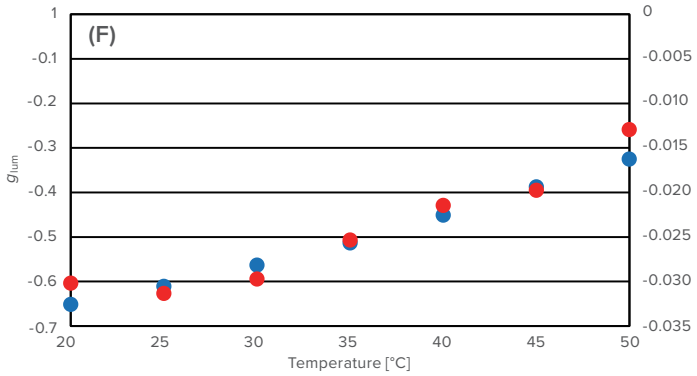
(6) Y. Kondo, S. Suzuki, M. Watanabe, A. Kaneta, P. Albertini, K. Nagamori, K: *Front. Chem.*, **8** (527), 1 (2020)

Temperature control measurement

It is often beneficial to evaluate the temperature dependence of CPL characteristics[7, 8] JASCO employs a temperature controlled thermo-electric peltier cell holder to be used in the CPL-300 or J-1500 CD spectrometer[6].







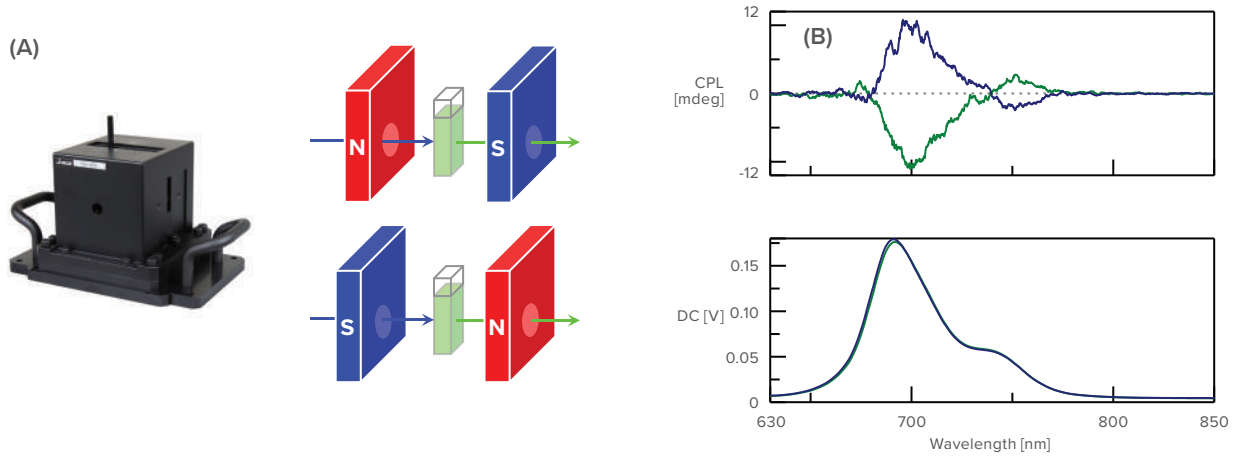
(A) Sample compartment of CPL-300 equipped with PTC-510 Peltier thermostatted cell holder (B) CD/absorption spectra of Eu(facam)$_3$/DMSO, (C) CD/absorption spectra of Eu(facam)$_3$/KBr pellet, (D) CPL/fluorescence spectra of Eu(facam)$_3$/DMSO, (E) CPL/fluorescence spectra of Eu(facam)$_3$/KBr pellet, and (F) g_{lum} for DMSO solution (blue) and KBr pellet (red) at 596 nm.

(6) Y. Kondo, S. Suzuki, M. Watanabe, A. Kaneta, P. Albertini, K. Nagamori, K: *Front. Chem.*, **8** (527), 1 (2020)
(7) Y. Okazaki, T. Goto, R. Sakaguchi, Y. Kuwahara, M. Takafuji, R. Oda, H. Ihara: *Chem. Lett.*, **45** (4), 448 (2016)
(8) J. Kumar, T. Nakashima, H. Tsumatori, T. Kawai: *J. Phys. Chem. Lett.*, **5**, 316 (2014)

Applications for CPL

Magnetic CPL

Magnetic CPL (MCPL) measurements on samples such as PMMA-film, KBr pellets and powder state are reported in literature by Imai and Fujiki et al.[9, 10].
The MCPL accessory measures CPL characteristics by applying a magnetic field parallel to the light axis inside the sample compartment.
The MCPL accessory fits both the CPL-300 and J-1500 sample compartments and provides complementary MCD and MCPL information on the same sample.

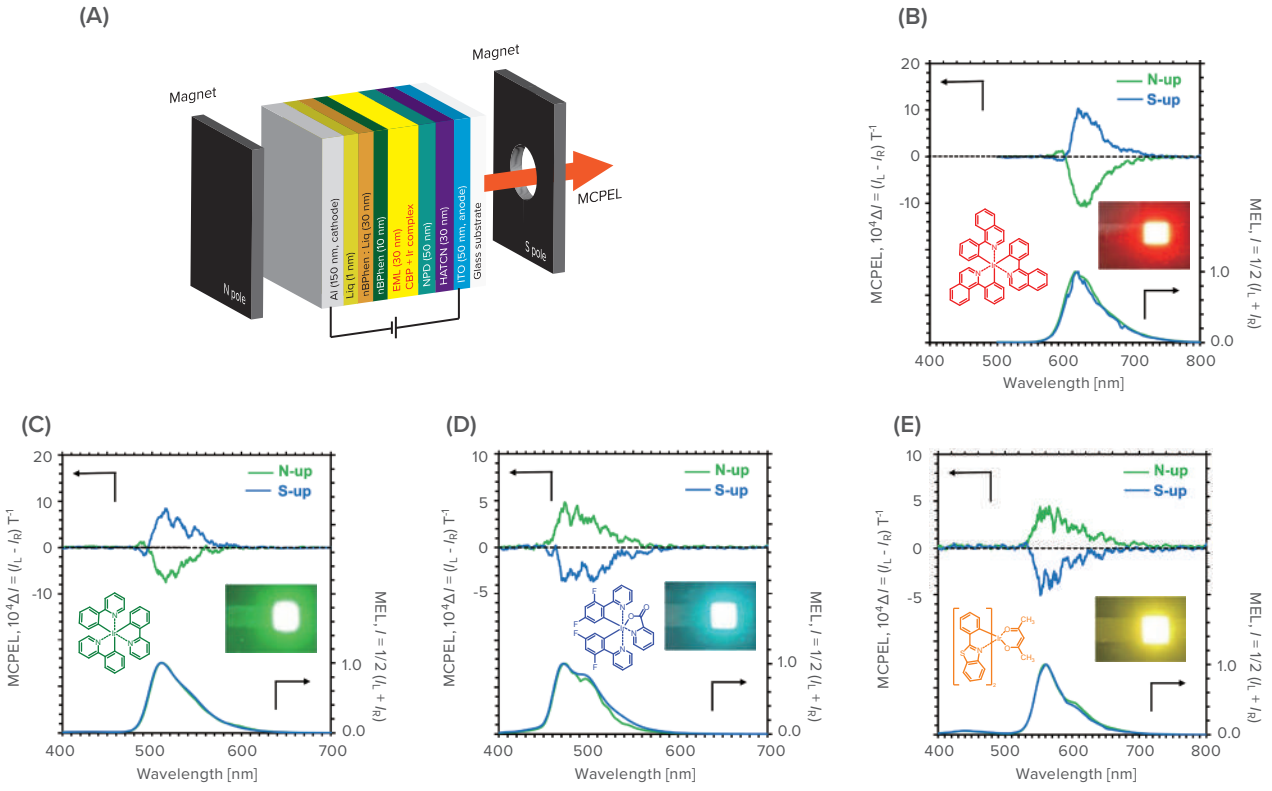


(A) PM-491 1.6 tesla compact permanent magnet and its overview (B) Magnetic CPL/fluorescence spectra of Phthalocyanine Zinc (green: light source side N, blue: light source side S).

(9) D. Kaji, H. Okada, N. Hara, Y. Kondo, S. Suzuki, M. Miyasaka, M. Fujiki, Y. Imai: *Chem. Lett.*, **49** (6), 674 (2020)
(10) H. Yoshikawa, G. Nakajima, Y. Mimura, T. Kimoto, Y. Kondo, S. Suzuki, M. Fujiki, Y. Imai: *Dalton Trans.*, **49**, 9588 (2020)

MCP-OLED

Circularly polarized organic light-emitting diode (CP-OLED) devices have been actively developed in recent years. Imai et al. have developed magnetic circularly polarized OLED (MCP-OLED) devices in which CP-OLED is induced by applying a magnetic field to a device incorporating an optically inactive iridium(III) luminophores embedded into the light-emitting layer.[11] They then succeeded in developing red-green-blue-yellow (RGBY) full-color devices (B-E). CPL-300, a small permanent magnet, and a dedicated sample holder for the device were utilized in this research.



(A) measurement overview (B) (C) (D) (E) magnetic circularly polarized electroluminescence (MCPEL, upper) and magnetic electroluminescence (MEL, lower) spectra of R–$Ir^{III}(piq)_3$, G-$Ir^{III}(ppy)_3$, B–$Ir^{III}(F_2\text{-}ppy)_2(pic)$ and Y–$Ir^{III}(BT)_2(acac)$ devices under 1.7 T N-up (green lines) and S-up (blue lines) geometric magnetic fields, respectively.

(11) M. Kitahara, K. Hara, S. Suzuki, H. Iwasaki, S. Yagi, Y. Imai,: *Organic Electronics*, **119**, 106814 (2023)

Data courtesy of Prof. Yoshitane Imai, Department of Applied Chemistry, Faculty of Science and Engineering, Kindai University, Japan.

Specifications

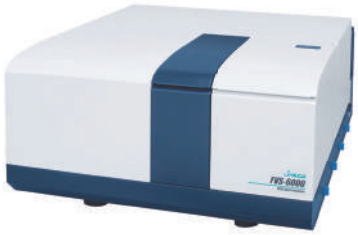
Model	CPL-300
Light source	150 W Ozone-free air-cooled Xe lamp 150 W air-cooled HgXe lamp (option)
Detector	Head-on photomultiplier tube PMT
Modulator	Photoelastic modulator
Electronic system	Lock-in amplifier
Monochromator	Double prisms monochromators for both Ex (excitation) and Em (emission) optics
Measurement wavelength range	250 to 850 nm 400 to 1100 nm (optional PMT detector)
Wavelength accuracy	±0.2 nm (250 to 500 nm) ±0.5 nm (500 to 800 nm) ±1.5 nm (800 to 1100 nm)
Wavelength reproducibility	±0.05 nm (250 to 500 nm) ±0.1 nm (500 to 800 nm) ±0.5 nm (800 to 1100 nm)
Slit width	1 to 4000 µm (automated by software)
Digital Integration Time (D.I.T.)	0.1 msec. to 30 sec.
Scanning mode	Continuous scan, Step scan, Auto response (D.I.T) scan
Scanning speed	up to 10000 nm/min.
Photometric mode	CD (AC component = CPL), DC (DC component = Fluorescence), HT (PMT High tension voltage), and AC/DC
CPL resolution	0.00001 mdeg
Wavelength resolution	0.025 nm
Stray light	0.001 % or less
External input terminal	Two channels (input range: -1 to 1 V DC)
Mercury lamp	Used for instrument inspection
Shutter	Located on both the Ex and Em monochromators
Sample compartment	150 mm (W) × 310 mm (D) × 165 mm (H)
Dimension/Weight	2000 mm (W) × 700 mm (D) × 1000 mm (H), 180 kg
Power	100 to 240 V 50/60 Hz, 430 VA
Software	Spectra Manager™

JASCO chiroptical spectroscopy

Circular dichroism spectrometer

J-1100/1500

The J-1000 Series Circular Dichroism (CD) spectrometers are specifically designed for high sensitivity measurements in the near and far-UV regions. Chiroptical spectroscopy has become one of the most important techniques for the characterization of biomolecules, determination of absolute configuration and stereochemical analysis.



Vibrational circular dichroism

FVS-6000

JASCO's VCD system is capable of measuring conventional IR Absorption along with Vibrational CD and is controlled by the Spectra Manager™ II spectroscopy software suite.

- **Digital Signal Processing (DSP) enhances sensitivity**
- **Thermally stabilized modulator system eliminates baseline drift**
- **Extra large dewar allows up to 15 hours of operation without refill**
- **Auto-alignment system eliminates linear anisotropy artifacts**
- **High-intensity ceramic light source for maximum energy and lifetime up to 10 years**

Digital polarimeter

P-2000

The P-2000 polarimeter is designed as a customizable polarimeter with various options for an array of applications and budgetary requirements. The system can be upgraded in the field as applications change. Options for wavelength filters and source lamps provide a wide range of analytical wavelengths from the UV-Vis to NIR.

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CERTIFIED

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DE6701-2310-01