円二色性分散計
Circular Dichroism spectrometer (CD)

## 基本仕様 / Specifications

日本分光株式会社（JASCO）J-1500

- 光源 / Light source : 150 W air-cooled Xenon lamp
- 検出器 / Detector : Head-on photomultiplier tube PMT
- 変調器 / Modulator : Photoelastic modulator
- 測定波長範囲 / Measurement wavelength range : 163 - 950 nm

- バンド幅 / Spectral bandwidth : 0.01 - 16 nm
- スリット幅 / Slit width : 1 – 4000 μm
- レスポンス / Digital Integration Time (D.I.T.) : 0.1 msec - 30 sec
- スキャンスピード / Scan speed : 1 – 10000 nm/min
- CDフルスケール / CD full scale : ± 8000 mdeg
- CD分解能 / CD resolution : 0.00001 mdeg
- LDフルスケール / LD full scale : ± 1 ΔOD
- LD分解能 / LD resolution : 0.000001 ΔOD

基本原理/ Mechanism

電磁波は、直行する電場と磁場中を進行方向に垂直に振動して伝わる横波です。自然界の光には、様々な向きに振動する光の成分が含まれています。これに対し、振動面がそろった光が直線偏光（左図上）、光の波の進行に伴い振動面が回転する偏光が円偏光です（左図下）。

Electromagnetic waves contain electrical and magnetic field components that oscillate perpendicularly to the direction of propagation of the light beam. In natural light, these components vibrate in many directions. On the other hand, in linearly polarized light, these vibrations are confined to a single plane (left Fig., upper). Another form of polarization is circularly polarized light, in which the vibration plane rotates as the light beam propagates (left Fig., lower).
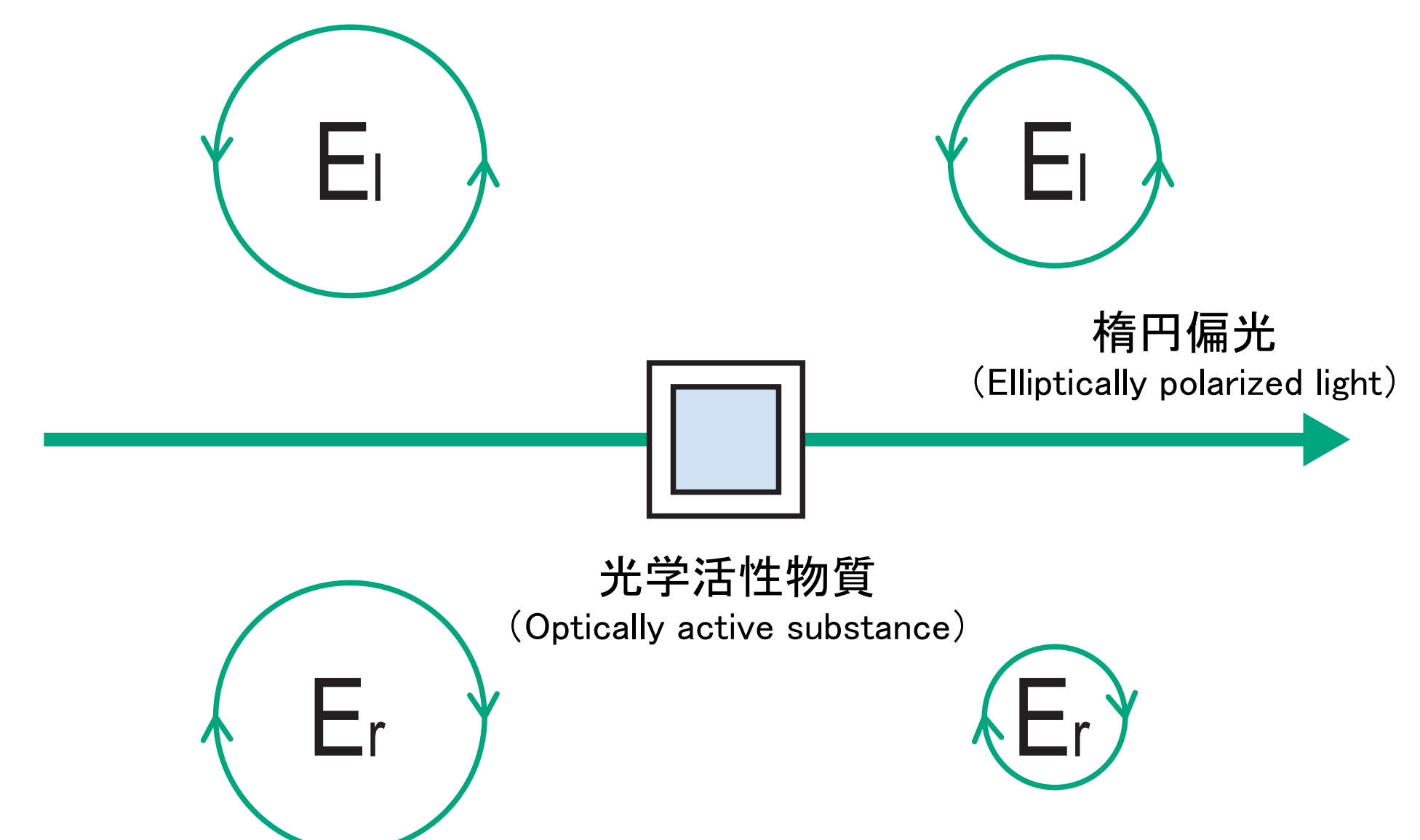
直線偏光
（Linearly polarized light）

円偏光
（Circularly polarized light）
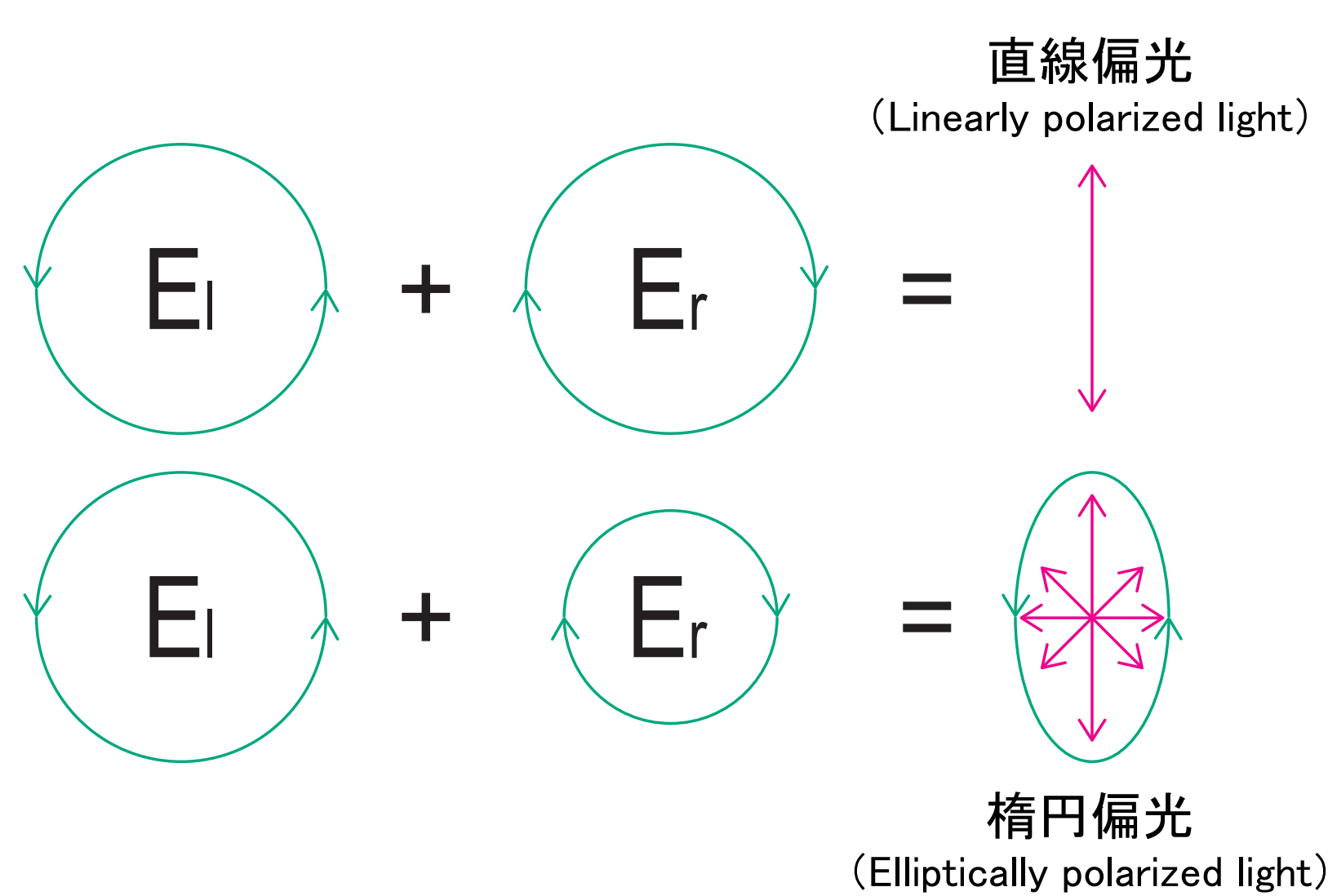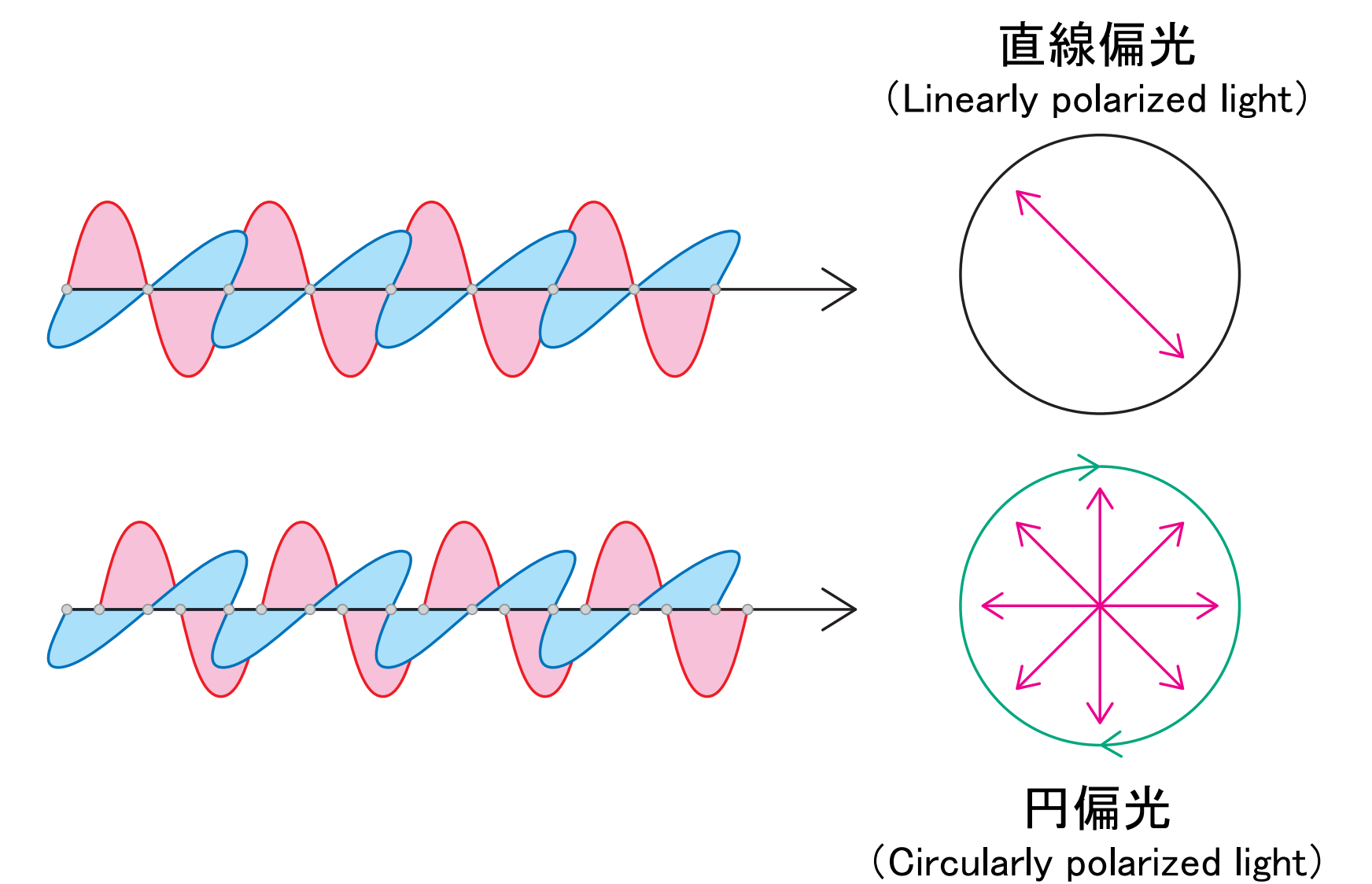
直線偏光は、結晶軸や分子の向きが揃った光学素子（偏光子）に光を通過させることで得られます。円偏光は、直行する波のベクトル（電場ベクトル）の位相が1/4波長ずれたときに生じます。円偏光には左回り円偏光（E_l）と右回り円偏光（E_r）とがあり、直線偏光は計算上、強度の等しいE_lとE_rの和と考えることができます（左図上）。強度が異なる場合のE_lとE_rの和が楕円偏光です（左図下）。

Linear polarization is obtained by passing light through an optical element (polarizer) in which the crystal axes and the orientation of the molecules are aligned. Circular polarization occurs when the phase of an orthogonal wave vector (electric field vector) deviates by 1/4 wavelength. Circularly polarized light can be left-handed (E_l) and right-handed (E_r), and linearly polarized light can be treated as the sum of E_l and E_r of equal intensity (left Fig., upper). When E_l and E_r have different intensities, the resulting light is referred to as elliptically polarized (left Fig., lower).

$E_l + E_r = $ 直線偏光（Linearly polarized light）

$E_l + E_r = $ 楕円偏光（Elliptically polarized light）

円二色性（circular dichroism: CD）は、光学活性物質の吸収波長領域において、左右円偏光の吸収の度合が異なる現象です。CD測定は、光学活性な試料に左右の円偏光を通すことで、それらの吸収の差を検出します。左右の円偏光の吸収の差により透過光は楕円偏光となり、この不等吸収の現象を円二色性（CD）と呼び、楕円率θで表します（左図）。この楕円率の波長依存性をプロットしたものを円二色性スペクトル（CD スペクトル）と呼びます。

Circular dichroism (CD) is a phenomenon in which the degree of absorption of left and right circularly polarized light is different in the absorption wavelength range of optically active substances. CD measurements detect these differences by passing left and right circularly polarized light through an optically active sample. The transmitted light is then elliptically polarized, and this phenomenon is called circular dichroism (CD) and is expressed by the ellipticity θ (left Fig.). A plot of the wavelength dependence of this ellipticity is called a circular dichroism spectrum (CD spectrum).

E_l 楕円偏光（Elliptically polarized light）

光学活性物質（Optically active substance）

E_r

出典：日本分光株式会社HP https://www.jasco-global.com/principle/principles-of-cd-ord-1/

実用例/ Application Example

出典：日本分光株式会社HP
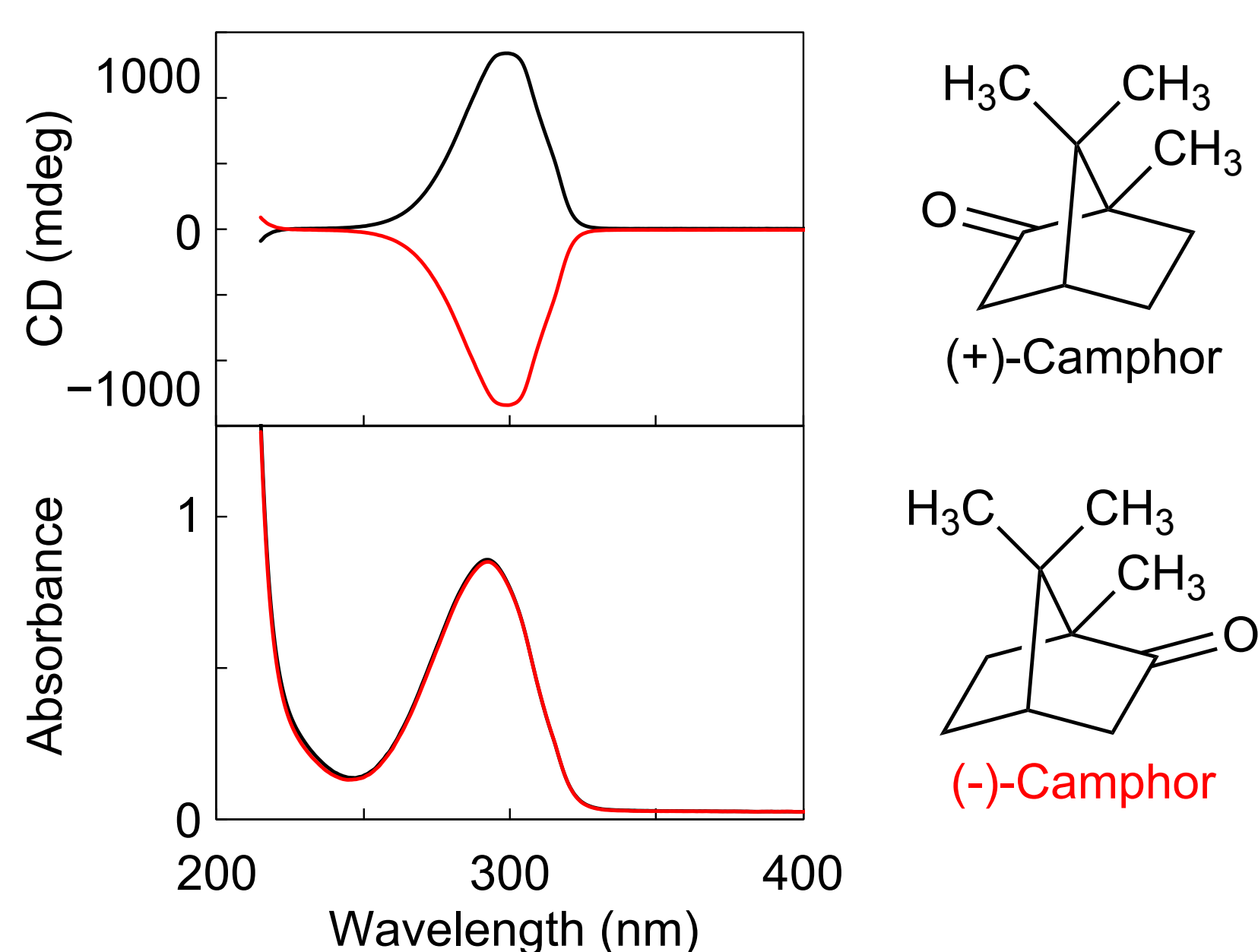https://www.jasco.co.jp/jpn/technique/internet-seminar/cdord/cd4.html

Figure 1 CD (top) and absorption (bottom) spectra of 0.4 w/v% camphor in ethanol.
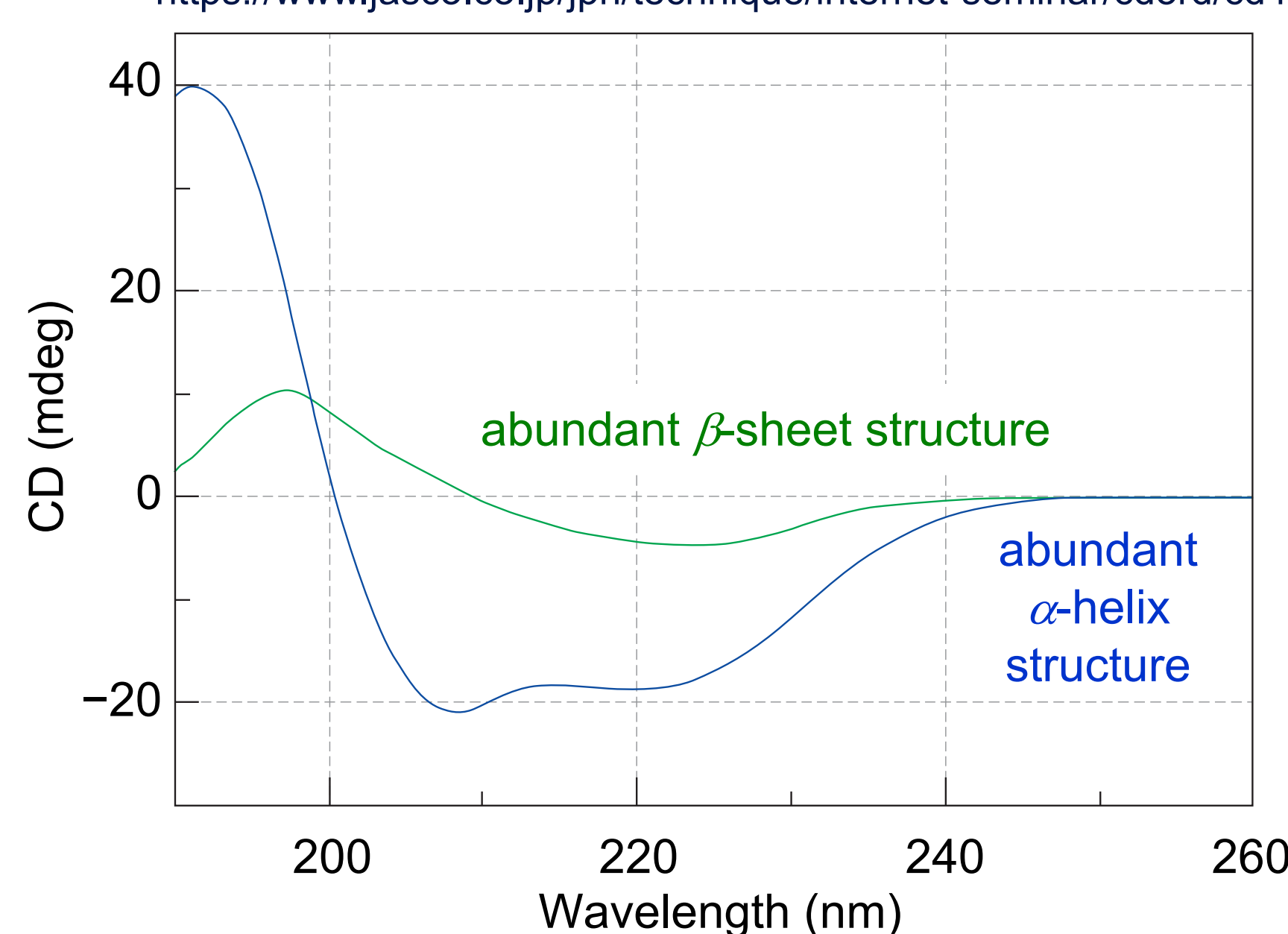
(+)-Camphor
(-)-Camphor

Figure 2 CD spectra of Concanavalin A in hydrochloric acid (pH = 2) aq. before (green line) and after adding TFE with a ratio of 1:1 (blue line).

abundant β-sheet structure
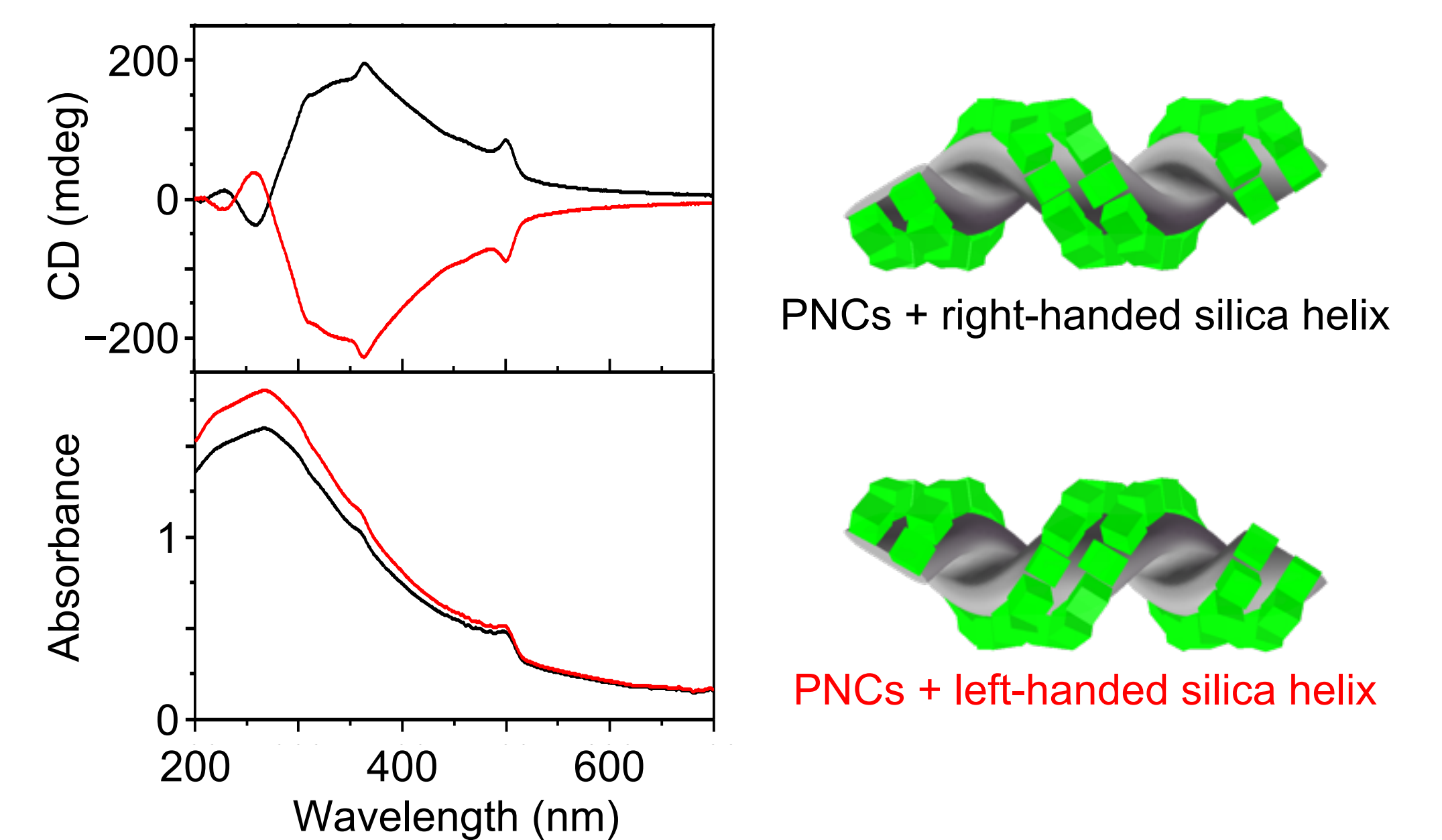abundant α-helix structure

Figure 3 CD (top) and absorption (bottom) spectra of perovskite nanocrystals (PNCs) grafted on silica helix in the dried film.

PNCs + right-handed silica helix
PNCs + left-handed silica helix

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