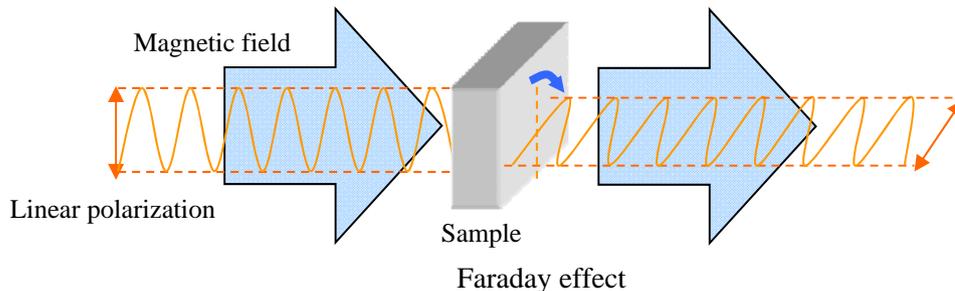


PM-491 Permanent Magnet (small type), 1.6 Tesla

Introduction

When a linear polarization is passed through the material in the magnetic field parallel to the direction of the magnetic field, the polarization plane is rotated. This phenomenon is termed the Faraday effect after the discoverer, which is regarded as optical activity induced by magnetic field.



ORD and CD are used for the observation of the Faraday effect as well as optically active materials. These experiments are named Magnetic Optical Rotary Dispersion (MORD) and Magnetic Circular Dichroism (MCD), respectively, due to phenomenon induced by the magnetic field. Although both the MORD and MCD can be measured by setting the magnet in the sample compartment for the ORD and CD respectively, MCD is widely used today due to simple measurement and high-sensitivity.

Previously, to generate a strong magnetic field over 1 Tesla, a large electrical magnet was used. The electrical magnet cannot be easily set in the sample compartment due to a weight of over 60 kg although it has an advantage that measurements can be performed while changing the intensity of the magnetic field. The PM-491 permanent magnet (small type) can provide a strong magnetic field of 1.6 Tesla. It is also available for the observation of small MCD signals such as a low-concentration sample. In addition, the PM-481 magnet can be easily set in the sample compartment due to its small size. The direction of the magnetic field can be changed by a simple switch to the reverse direction.

MCD is a phenomenon which is observed for all materials in principle. The normal CD spectra provides the configuration and conformational information, whereas the MCD spectra provides the electronic state information.

Measurement examples for the neodymium glass, cytochrome C and cobalt chloride (II) 6 hydrate are shown in the following pages



PM-491 Permanent magnet, 1.6 Tesla

Intensity of magnetic field: 1.6 Tesla
Cell length: 5 mm (option: 1 mm, 2 mm)

Keyword: Faraday effect, Magnetic Circular Dichroism, Magnetic Optical Rotary Dispersion, cytochrome C, Soret

MCD of neodymium glass

Neodymium glass is optically inactive, however it illustrates MCD spectra from the UV/Vis to the NIR range using the generated magnetic field. Not only do the spectra demonstrate strong sharp MCD signals (Fig. 1) which have strong optical absorptions but also the small MCD signals due to weak optical absorptions are displayed (Fig. 2) due to the extremely strong magnetic field of 1.6 T. MCD spectra can also separate sharp peaks which cannot separate in the absorption spectra. In this application note (please see the “supplemental explanation” in the last page), if the direction of the magnetic field is the same as that of the measurement light, it is defined as the magnetic field in the forward direction. If the direction of the magnetic field is different from that of the measurement light, it is defined as the magnetic field in the inverse direction. By changing the direction of the magnetic field, the code of the MCD spectra is also reversed.

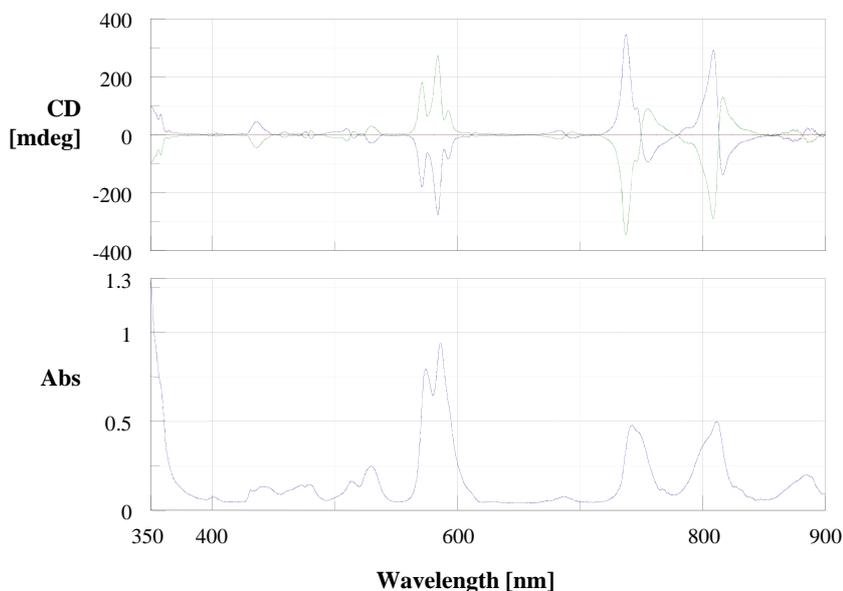


Fig. 1 MCD and absorption spectra of a neodymium glass sample (900 - 350 nm)

Blue line: Magnetic field in the forward direction
 Green line: Magnetic field in the inverse direction
 Red line: without magnetic field

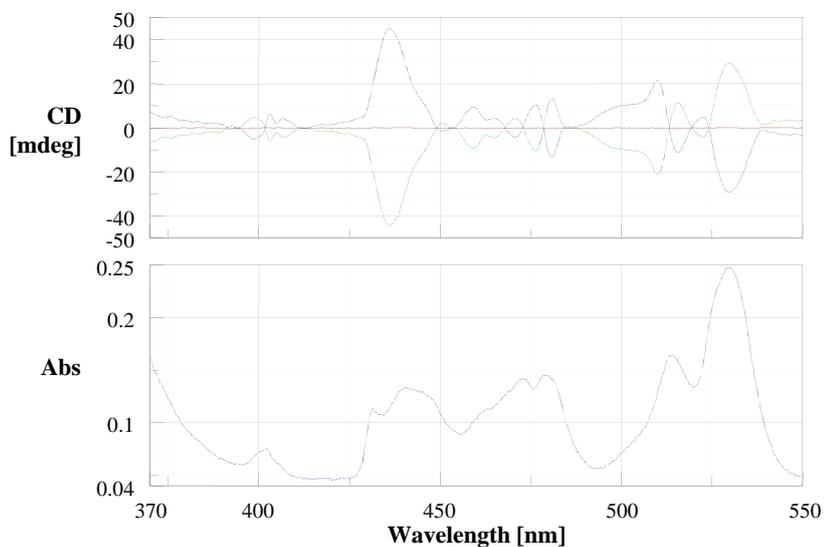


Fig. 2 MCD and absorption spectra of the neodymium glass (550 - 370 nm)

Blue line: Magnetic field in the forward direction
 Green line: Magnetic field in the inverse direction
 Red line: without magnetic field

MCD of Fe (III) cytochrome c (derived from equine heart)

MCD is widely used for the structural analysis of hemoprotein samples, and several studies of myoglobin¹⁾, hemoglobin²⁾, cytochrome b_5 ^{3), 4)}, cytochrome c ^{3), 5), 6)}, cytochrome P-450⁷⁾ and horseradish peroxidase⁸⁾ are reported. The measurement examples for the MCD spectra in the Soret band of the Fe (III) cytochrome C solution are shown below.

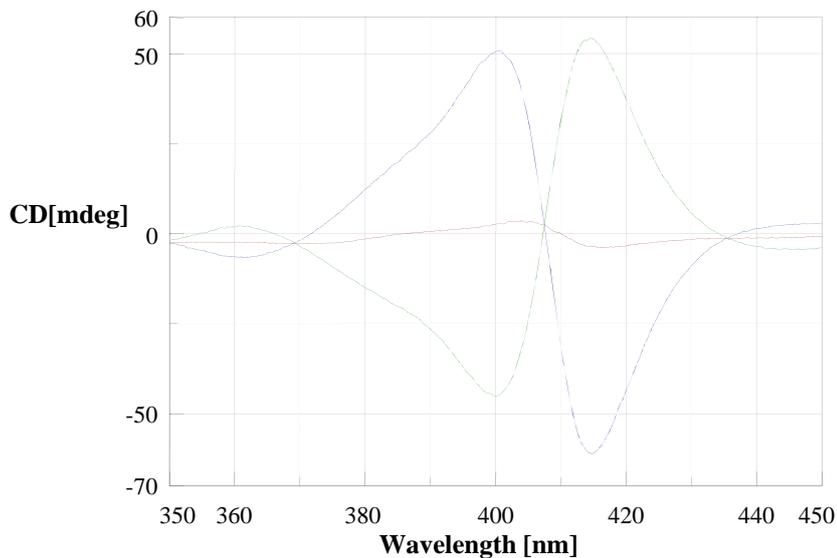


Fig. 3 MCD spectra and CD spectrum of the Fe (III) cytochrome C

Blue line: Magnetic field of forward direction
 Green line: Magnetic field of inverse direction
 Red line: without magnetic field (CD spectra)

If the CD spectrum obtained with the non-magnetic-field condition is subtracted from the MCD spectra, the symmetric MCD spectra can be observed.

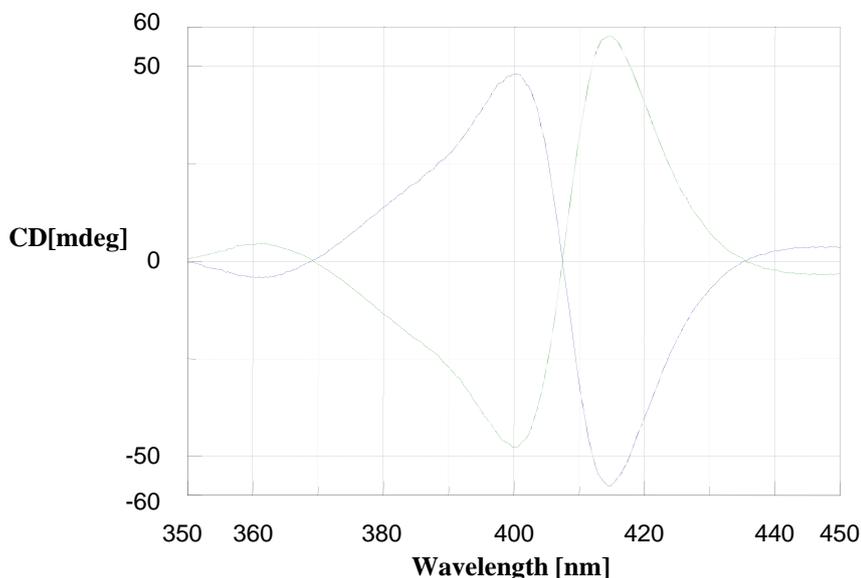


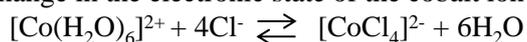
Fig. 4 MCD spectra of the Fe(III) cytochrome C (after subtraction of the CD spectrum)

Blue line: Magnetic field of forward direction

Green line: Magnetic field of inverse direction

MCD of cobalt chloride (II) 6 hydrate

An aqueous solution of cobalt chloride (II) 6 hydrate exists in a 6-coordinate structure of the octahedron type in which the cobalt ion is coordinated with 6 water molecules (Figure 5). By contrast, the cobalt chloride (II) 6 hydrate in a concentrated hydrochloric acid solution is a 4-coordinate structure of a tetrahedron type in which it is coordinated with 4 chloride ions (Figure 6). The MCD spectra demonstrate drastic changes based on the change in the electronic state of the cobalt ion with high-sensitivity⁹⁾.



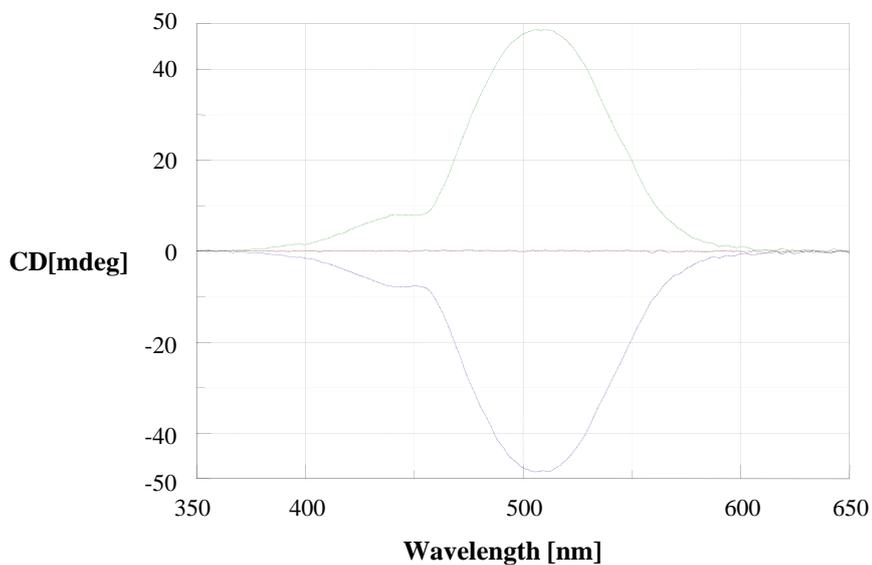


Fig. 5 MCD spectra of cobalt chloride (II) 6 hydrate in aqueous solution
 Blue line: Magnetic field in the forward direction
 Green line: Magnetic field in the reverse direction
 Red line: without magnetic field

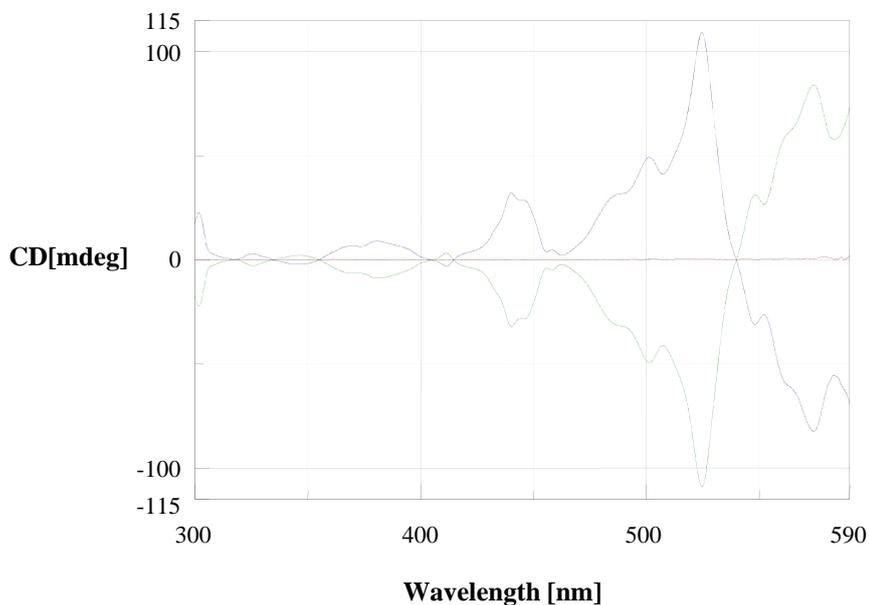
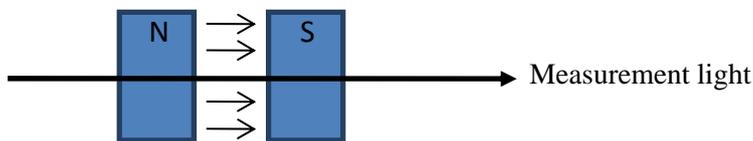


Fig. 6 MCD spectra of cobalt chloride (II) 6 hydrate in concentrated hydrochloric acid
 Blue line: Magnetic field in the forward direction
 Green line: Magnetic field in the reverse direction
 Red line: without magnetic field

Supplemental explanation: Directional relation between measurement light and magnetic field



The direction of the magnetic field is the same as that of the measurement light:
--> Magnetic field in the **forward direction**



The direction of the magnetic field is different from that of the measurement light:
--> Magnetic field in the **inverse direction**

Reference

- (1) L. Vickery, T. Nozawa, and K. Sauer, *J. Am. Chem. Soc.*, 98, 343 (1976)
- (2) S. Yoshida, T. Iizuka, T. Nozawa and M. Hatano, *Biochim. Biophys. Acta.*, 405, 122 (1975)
- (3) L. Vickery, T. Nozawa, and K. Sauer, *J. Am. Chem. Soc.*, 98, 351 (1976)
- (4) L. Vickery, A. G. Salmon, and K. Sauer, *Biochim. Biophys. Acta*, 386, 87 (1975)
- (5) B. Briat, D. Berger, and M. Leliboux, *J. Chem. Phys.*, 57, 5606 (1972)
- (6) N. Kobayashi, T. Nozawa, and M. Hatano, *Bull. Chem. Soc. Jpn.*, 54, 919 (1981)
- (7) T. Shimizu, T. Nozawa, M. Hatano, Y. Imai, and R. Sato, *Biochemistry*, 14, 4173 (1975)
- (8) T. Nozawa, N. Kobayashi, and M. Hatano, *Biochim. Biophys. Acta.*, 427, 652 (1976)
- (9) D. A. Schooley, E. Bunnenberg, and C. Djerassi, *Chemistry*, 53, 579, (1965)