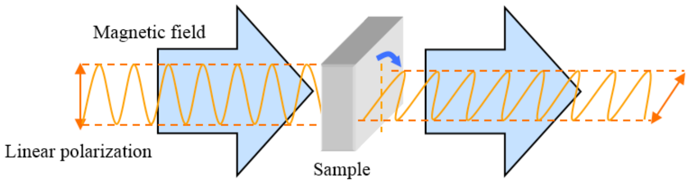
Application Note
CD Spectroscopy

Measurement of magnetic CD with the PM-491 permanent magnet

Introduction

When linearly polarized light is passed through a material in a magnetic field parallel to the direction of the magnetic field, the polarization plane is rotated. The use of a magnetic field to induce optical activity in molecules is also known as the Faraday effect.



Faraday effect

ORD and CD can be used to observe these magnetic field-induced optically active molecules. These techniques are more commonly known as magnetic optical rotary dispersion (MORD) and magnetic circular dichroism (MCD). MCD is widely used today to probe the local environment of protein molecules. Chromophores with large magnetic moments arising from either rotational symmetries (aromatics, porphyrins), unpaired spins (metal complexes), or both (hemes) are sensitive to electronic perturbations and therefore provide information regarding the molecule's electronic state. The MCD signal intensity is proportional to the magnetic field strength, which can be applied by using a permanent magnet.

Previously, in order to generate a strong magnetic field (greater than 1 Tesla) a large electromagnet was required. However, this type of electromagnet cannot easily be set inside the sample compartment of a CD spectrometer due to its excessive weight (typically greater than 60 kg). Recently JASCO has introduced the PM-491 permanent magnet. The PM-491 has a magnetic field of 1.6 Tesla and is compact so it easily fits inside the spectropolarimeter sample compartment. The direction of the magnetic field can be changed by simply reversing the direction of the magnet.

PM-491 permanent magnet, 1.6 Tesla
View product information at www.jascoinc.com

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This application note provides examples of the J-1500 CD spectrometer and PM-491 permanent magnet to obtain MCD measurements.

Keywords

J-1500, circular dichroism, magnetic circular dichroism, Faraday effect, UV-Vis, NIR, biochemistry, chemical

Experimental

Measurement conditions			
	Neodymium glass	**Cytochrome C**	**Cobalt chloride (II) 6 Hydrate**
Data acquisition interval	0.5 seconds	2 seconds	2 seconds
Spectral bandwidth	1 nm	1 nm	1 nm
Scan speed	50 nm/min	20 nm/min	100 nm/min
Path length		0.2 cm	0.5 cm

Results

Neodymium glass is optically inactive. However, when subjected to a magnetic field an MCD spectrum from the UV-Visible to NIR region can be observed. The spectra in Figure 1 show sharp MCD signals caused by strong optical absorption. Figure 2 shows that small MCD signals caused by weak optical absorptions can be enhanced by the strong 1.6 T magnetic field. MCD spectra illustrate sharp peaks that cannot be separated in the absorption spectra.

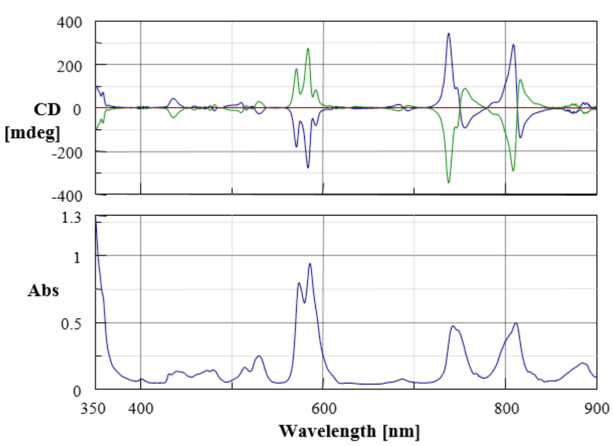

Figure 1. MCD (top) and absorption (bottom) spectra of neodymium glass in the NIR region. The blue spectra show the magnetic field in the forward direction, the green illustrate the magnetic field in the reverse direction, and red spectra are in the absence of a magnetic field.

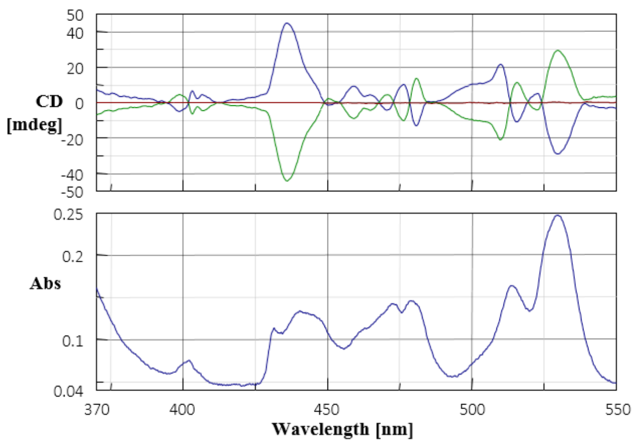

Figure 2. MCD (top) and absorption (bottom) spectra of neodymium glass in the UV-Vis region. The blue spectra show the magnetic field in the forward direction, the green illustrate the magnetic field in the reverse direction, and red spectra are in the absence of a magnetic field.

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If the direction of the magnetic field is the same as that of the incoming light, the magnetic field can be defined as being in the forward direction. If the direction of the magnetic field is opposite to that of the incoming light, it is defined as the magnetic field in the reverse direction. This is depicted in Figure 3. By changing the direction of the magnetic field, the MCD spectra can also be reversed.

Figure 3. The magnetic field in the forward direction (left) and the magnetic field in the reverse direction (right).

MCD of Fe (III) cytochrome c

MCD is widely used for the structural analysis of hemoprotein samples and several studies of myoglobin[1], hemoglobin[2], cytochrome b_5[3-4], cytochrome c[3,5-6], cytochrome P-450[7], and horseradish peroxidase[8] are reported. The MCD spectra of the Soret band of Fe(III) cytochrome in solution are shown in Figure 4. If the CD spectrum obtained in the absence of a magnetic field is subtracted from the MCD spectra, symmetric MCD spectra can be observed.

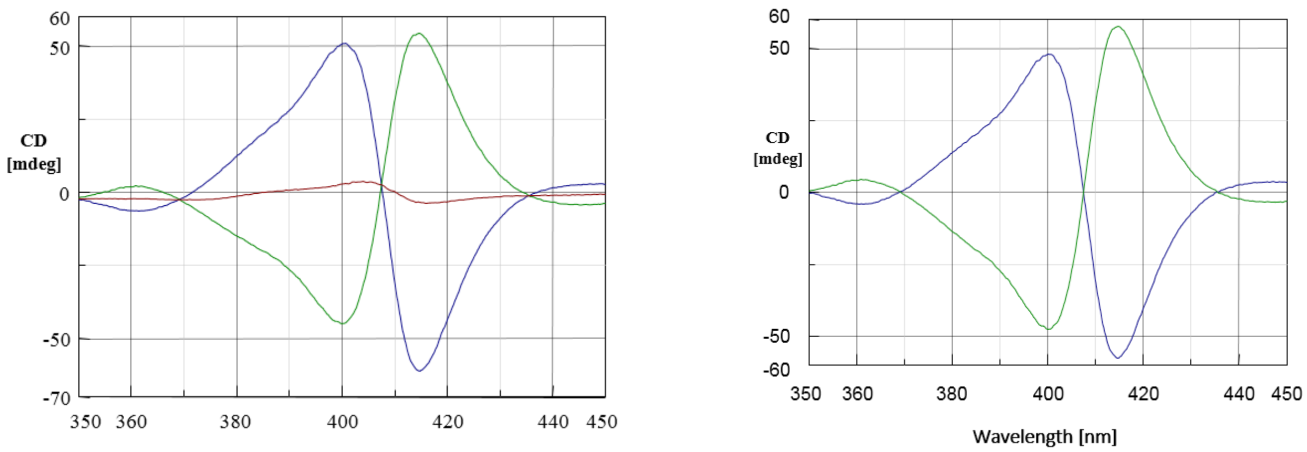

Figure 4. MCD spectra of Fe(III) cytochrome c before (left) and after (right) subtraction of the CD spectrum. The blue spectra show the magnetic field in the forward direction, the green illustrate the magnetic field in the reverse direction, and red spectra are in the absence of a magnetic field.

MCD of cobalt chloride (II) 6 hydrate

An aqueous solution of cobalt chloride (II) 6 hydrate exists as a hexacoordinated structure where the cobalt ion is coordinated with six water molecules. Conversely, cobalt chloride 6 hydrate in a concentrated HCl solution exists as a tetrahedron complex in which the cobalt ion is coordinated to four chloride ions. The MCD spectra illustrate drastic changes based on the change in the electronic state of the cobalt ion and are shown in Figures 5 and 6.

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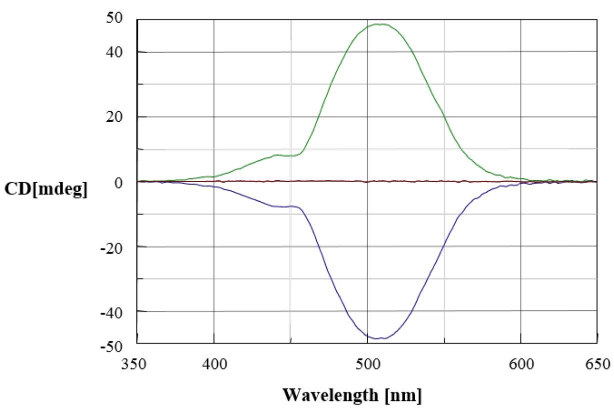

Figure 5. MCD spectra of cobalt chloride (II) 6 hydrate in aqueous solution. The blue spectra show the magnetic field in the forward direction, the green illustrate the magnetic field in the reverse direction, and red spectra are in the absence of a magnetic field.

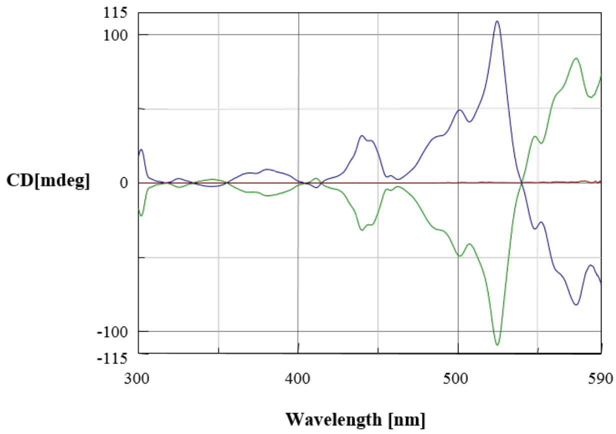

Figure 6. MCD spectra of cobalt chloride (II) 6 hydrate in concentrated hydrochloric acid solution. The blue spectra show the magnetic field in the forward direction, the green illustrate the magnetic field in the reverse direction, and red spectra are in the absence of a magnetic field.

Conclusion

This application note illustrates that the J-1500 CD spectrometer and the PM-491 permanent magnet can be used to obtain magnetic circular dichroism spectra for a variety of samples.

References

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