Construct, Conduct & Comprehend Physics Experiments

LEOK-3–28 Studying on the Effect of Optical Activity & Its Application

- *Complete set*
- *Cost effective solution*
- *Detailed instructional manual*
- *Easy alignment*

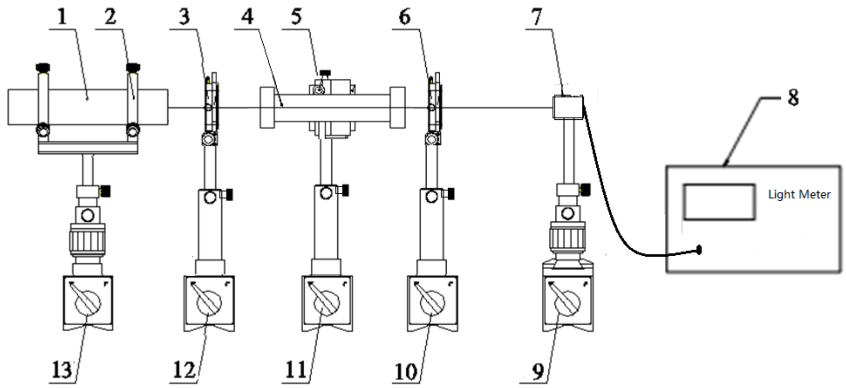

Figure 28-1 Schematic of experiment setup

1: He Ne Laser (LLL-2)
2: Laser Holder (SZ-42)
3, 6: Polarizer with Rotary Holder (SZ-51)
4: Sample Tube
5: Grating/Prism Holder (SZ-10)
7: Photo Sensor
8: Light Meter
9 - 13: Magnetic Base (SZ-04)

Theory

When linearly polarized light passes through certain solid substances or solutions, the plane of polarization of the light rotates a certain angle. This phenomenon is called the effect of optical activity and the optical rotary angle is called the specific rotation of the substance. The specific rotation of a solution depends on a number of parameters such as the substance in the solution, the concentration of solution, the sample path length, the temperature of solution, and the wavelength of light. If other parameters are fixed, then the specific rotation, ϑ, is linearly proportional to the concentration of solution, C, as

$$\theta = \beta C \tag{28-1}$$

where β depends on the substance in the solution, the sample path length, the temperature of solution, and the wavelength of light.

The polarization rotation ability of a substance can be further evaluated by its specific rotary power, as described by

$$[a]_{\lambda}^{T} = \frac{\theta}{lC} \tag{28-2}$$

where T represents the temperature of the solution (°C), l is the wavelength of monochromatic light (nm), ϑ is the specific rotation degree, l is the sample path length (dm), and C is the concentration of solution (g/1000 mL).

It is apparent from equation (28-2) that a) the plane of polarization of light rotates gradually as light propagates in the solution so that the specific rotation is proportional to the length of the sample; b) the specific rotation is also proportional to the concentration of the solution.

If the concentration of the solution and the sample path length are known, the specific rotary power of the solution can be calculated once the specific rotation is measured. This can be conducted by measuring the specific rotation while varying the solution concentration. From the slope of the obtained ϑ-C line, the specific rotary power of the substance can be derived. Similarly, if the specific rotary power of a substance is known, then its concentration in a solution under test can be determined once the specific rotation is measured.

The specific rotation of an optically active medium can be either left-handed or right-handed. When viewed against the propagation direction of light, if the specific rotation is clockwise, then the substance is called a right-handed substance; if the specific rotation is counter-clockwise, then the substance is called a left-handed substance.

Experiment Procedures

1. Observe the Polarization Phenomenon of Light

1) Per Figure 28-1, don't place the sample cell at this time, adjust the laser beam to make it parallel to the optical table with a height equal to those of the polarizer and the photo sensor.
2) Rotate the polarizer with its rotary holder until the transmitted laser intensity reaches a maximum value as detected by the photo sensor (in case the laser is polarized).
3) Insert the analyser in between the polarizer and the photo detector. Adjust the analyser to make it coaxial with the polarizer with the same height.
4) Rotate the analyser until the transmitted laser intensity reaches a minimum value as indicated by the photo sensor. Now the axes of the polarizer and the analyser are perpendicular to each other.
5) Continue to rotate the analyser until the transmitted laser intensity reaches another minimum value. Check the angular reading of the analyser, it should be 180° with respect to its previous reading.

2. Observe the Polarization Rotation Characteristics of Glucose Solution

1) Before placing the sample cell to the optical path, make sure the axes of the polarizer and the analyser are still perpendicular to each other. Add glucose solution into the cell and mount the sample cell onto the grating/prism holder (SZ-10), insert the sample cell in between the polarizer and the analyser, according to Figure 28-1.
2) Adjust the sample cell holder to make sure the laser spots incident on the sample cell and transmitted through the sample have the same shape when observed with a piece of white paper. This is to ensure the sample cell is coaxial with the laser beam at the same height.
3) As the sample cell is placed in the optical path, the light transmitting through the analyser increases due to the polarization rotation effect of the glucose solution.
4) Rotate the analyser until the transmitted light intensity reaches a minimum value again to judge if the polarization rotation of the glucose solution is left-handed or right-handed.
5) Read the angular reading of the analyser and the angle rotated by the analyser is the specific rotation angle of the glucose solution under test.

3. Measure the Specific Rotary Power of Glucose Solution

1) Make glucose solution with five different concentrations of 30% (C_0), 15% ($C_0/2$), 7.5% ($C_0/4$), 3.75% ($C_0/8$), and 0%, respectively.
2) Measure the specific rotation angle with respect to each glucose solution (for each glucose solution, repeat the measurement multiple times and then take the averaged data).
3) Record the ambient temperature during each measurement. Plot the curve of specific rotation angle versus solution concentration using the following table. Calculate the slope of the measured curve by curve-fitting to derive the specific rotary power of the glucose solution.

	Specific Rotation Angle θ(°)						$\bar{\theta}$(°)
	1	2	3	4	5	6	
C_0							
$C_0/2$							
$C_0/4$							
$C_0/8$							
0（Pure water）							

4. Measure the Concentration of Glucose Solution

Based on the above experiment results, if the specific rotary power of glucose solution is known, then the concentration of a glucose solution under test can be determined once its specific rotation is measured.

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