Rotation of the plane of polarization with sugar solutions

Objects of the experiments

- Observing the rotation of the plane of polarization by a concentrated sugar solution in an arrangement of two crossed polarizers.
- Determining the angle of rotation for three different colours of the light.

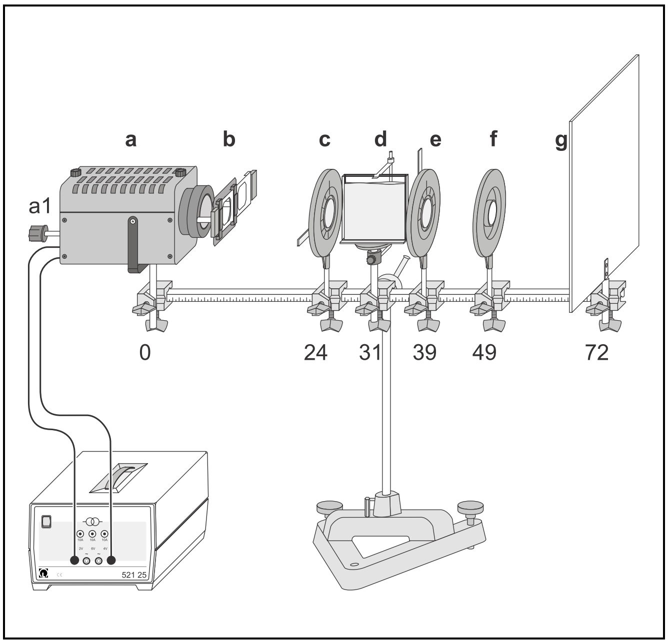

Fig. 1 Experimental setup for observing the rotation of the plane of polarization by a sugar solution.
a Halogen lamp housing
b Light filter (in picture slider)
c Polarizer
d Sugar solution
e Analyzer
f Lens
g Observing screen

Principles

Optical activity is a property of several substances by which the plane of polarization of linearly polarized light is rotated on passing through the substance. This phenomenon occurs, among other things, in some solutions. Here the molecular structure of the dissolved substance leads to right-circularly and left-circularly polarized light propagating at different phase velocities in the solution. Linearly polarized light which enters the solution can be decomposed into a right-circularly and a left-circularly polarized partial wave. The two partial waves propagate at different phase velocities so that a phase difference arises, which is proportional to the distance covered. After the two partial waves have covered this distance, their superposition results in a linearly polarized wave whose direction of polarization is rotated relative to the original wave.

The angle of rotation α depends on the molecular structure and the concentration of the dissolved substance, on the path length of the light in the solution and on the wavelength of the light. It is assigned a positive value if the plane of polarization of the light is rotated clockwise (right-hand rotation) as seen by an observer looking in the direction opposite to the light ray propagation. An anticlockwise rotation is called a left-hand rotation and is assigned a negative value.

Basically any optically active substance can occur in a right-rotating and in a left-rotating modification. The specific rotations of the two modifications are equal in magnitude and have different signs. Mixtures of both modifications reduce the angle of rotation. A mixture in which both modifications are present in equal proportions is called a racemate.

In the experiment the rotation of the plane of polarization is detected in an arrangement of two crossed polarizers. A concentrated solution of D(+)-saccharose in water is used as an optically active substance. The label D(+) already indicates that this substance leads to a right-hand rotation of the plane of polarization.

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Apparatus

1 D(+)-saccharose, 100 g	674 605
1 halogen lamp , 12 V/100 W	450 63
1 halogen lamp housing 12 V, 50/100 W	450 64
1 picture slider for halogen lamp housing	450 66
1 light filter, red	468 03
1 light filter, green	468 07
1 light filter, blue	468 11
1 transformer 2 … 12 V	521 25
1 plate glass cell 100 × 100 × 10 mm^3	477 20
2 polarization filters	472 401
1 lens, f = + 100 mm	460 03
1 prism table	460 25
1 translucent screen	441 53
1 small optical bench	460 43
1 stand base, V-shape, 28 cm	30001
6 Leybold multiclamps	301 01
1 spoon with spatula handle	666 963

Connecting leads with 2.5 mm^2 cross section

Setup

The experimental setup is illustrated in Fig. 1.

- Mount the components on the small optical bench according to Fig. 1, where the position of the left edge of the Leybold multiclamps is given.
- Align the polarization filters so that their scales point towards the observing screen, and set them both to 90°.
- Set up the halogen lamp housing for 100 W operation (use the reflector, see instruction sheet for halogen lamp housing).
- Align the halogen lamp with the adjusting rod **(a1)** of the lamp housing and shift the lens on the optical bench so that the field of view on the observing screen is uniformly illuminated.
- Fill 50 ml of water into the plate glass cell (filling level = 5 cm). Put the plate glass cell on the prism table, and align it so that it is centred in the field of view.

Carrying out the experiment

a) Observing white light:

- Set the analyzer to 0° and observe the entire field of view.
- Take the plate glass cell out of the ray path and cautiously pour about 20 spoonfuls of D(+)-saccharose into the water.
- Dissolve the D(+)-saccharose as completely as possible by carefully stirring.
- Align the plate glass cell in the centre of the ray path again, and observe the field of view.
- Rotation the direction of polarization of the analyzer and observe the entire field of view.

b) Observing monochromatic light:

- Insert the red light filter in the picture slider in front of the exit aperture of the halogen lamp housing, and adjust maximum darkness in the middle part of the field of view with the analyzer (see Fig. 2).
- Take the position of the analyzer down as the angle of rotation of the solution for red light.
- Replace the red light filter with the green one, and determine the angle of rotation again.
- Determine the angle of rotation for the blue light filter.

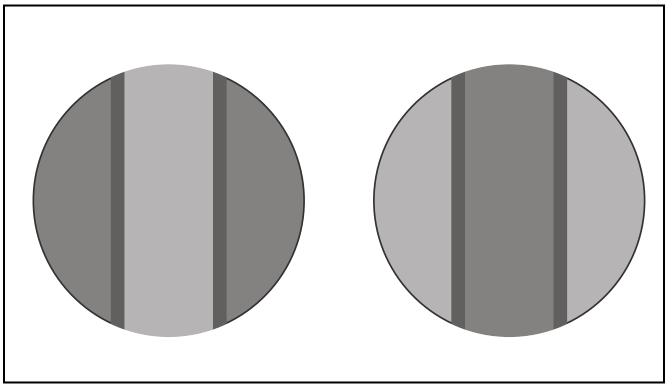

Fig. 2 Field of view for monochromatic light after the sugar solution has been put into the ray path (left: analyzer position 0°, right: maximum darkness in the middle part of the field of view)

Measuring example and evaluation

a) Observing white light:

Solution: 20 spoonfuls of D(+)-saccharose in 50 ml of water

The solution light up the field of view if the polarizer and the analyzer are perpendicular. Depending on the angular position, the colour of the field of view changes (secondary colours).

b) Observing monochromatic light:

Table 1: Angle of rotation for different colours of the light

filter	angle of rotation
red	25°
green	40°
blue	55°

Results

A solution of D(+)-saccharose in water is optically active. The angle of rotation of the plane of polarization is positive in accordance with the label D(+). It strongly depends on the wavelength of the light.