

Building a half-shadow polarimeter with discrete elements

Objects of the experiments

- Studying the principle of operation of a half-shadow polarimeter.
- Measuring the angle of rotation of a sugar solution as a function of the concentration.

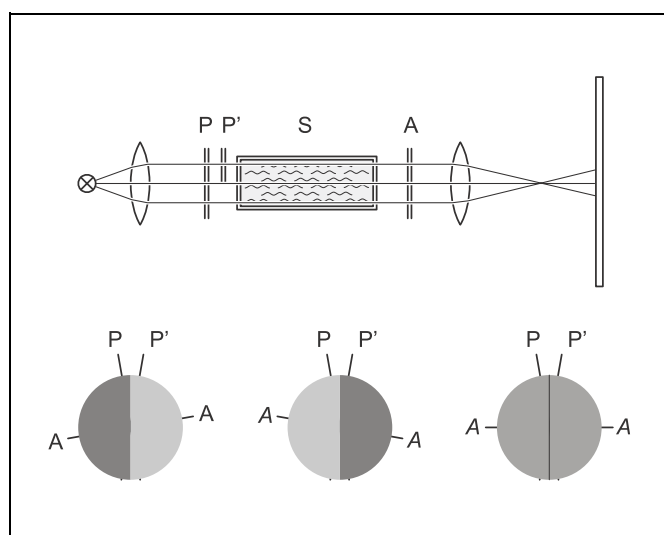


Fig. 1 Diagram illustrating the principle of operation of a half-shadow polarimeter (above: ray path, below: field of view for three different positions of the analyzer).

- P polarizer
P' half-shadow polarizer
A analyzer
S sample

Principles

The rotation of the plane of rotation by an optically active substance can be detected by means of two crossed polarizers. The angle of rotation is the angle to which the analyzer has to be set after the substance has been introduced into the ray path in order to re-establish maximum darkness of the field of view. As the accuracy to which the analyzer can be adjusted to maximum darkness is very limited, a slight rotation of the plane of polarization by a weakly optically active substance cannot be detected precisely.

A more precise criterion for adjusting the analyzer is provided by the Lippich half-shadow polarimeter. Here an additional polarization filter P' is inserted between the polarizer P and the sample S. P' covers half the field of view and its direction of polarization is rotated by a small angle relative to the polarizer (see Fig. 1 above). If the analyzer A is perpendicular to the polarizer P, the free half of the field of view is dark, and if it is perpendicular to the half-shadow polarizer, the covered half is dark (see Fig. 1 below). If the analyzer is set to a middle position, the two halves of the field of view are equally bright. This zero position can be adjusted very precisely because deviations from it are clearly seen due to the opposite changes in brightness on the two fields.

In the experiment the rotation of the plane of polarization by a sugar solution is measured as a function of the concentration, whereby the concentration is changed in small steps. The angle of rotation strongly depends on the wavelength of the light. Therefore a yellow colour filter is used in the experiment.

Apparatus

1 halogen lamp, 12 V/100 W	450 63
1 halogen lamp housing 12 V, 50/100 W . .	450 64
1 transformer 2 ... 12 V	521 25
1 picture slider for halogen lamp housing .	450 66
1 mercury light filter, yellow	468 30
2 polarization filters	472 401
1 lens, $f = + 100$ mm	460 03
1 translucent screen	441 53
1 holder with spring clips	460 22
1 polarizing foil	520 51 108
2 cover glasses 50×50 mm ²	463 80 111
1 prism table	460 25
1 plate glass cell $100 \times 80 \times 25$ mm ³	477 25
1 small optical bench	460 43
1 stand base, V-shape, 28 cm	30001
7 Leybold multiclips	301 01
1 D(+)-saccharose, 100 g	674 605
1 spoon with spatula handle	666 963
Connecting leads with 2.5 mm ² cross section	

Setup

The half-shadow polarizer P' is shown in Fig. 2 and the complete experimental setup is illustrated in Fig. 3.

Illumination of the field of view

- Mount the components (except the half-shadow polarizer) on the small optical bench according to Fig. 3, where the position of the left edge of the Leybold multiclips is given.
- Align the two 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), and insert the mercury light filter in the picture slider in front of the exit aperture.
- 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 100 ml of water into the plate glass cell (filling level = 5 cm). Put the plate glass cell lengthwise on the prism table, align it so that it is centred in the field of view, and clamp it.

Building the half-shadow polarizer:

- Determine the direction of polarization of the polarizing foil (520 51 108) by comparing with the polarization filter (472 401).
- Cut the polarizing foil into halves perpendicularly to the direction of polarization.
- Remove the protective foil from one half, and mount this half between two cover glasses in the holder with spring clips (see Fig. 2).

Inserting the half-shadow polarizer

- Introduce the half-shadow polarizer into the ray path.
- Remove the analyzer, set the polarizer to 0° , and align the half-shadow polarizer so that one half of the field of view is covered.
- Exactly determine the direction of polarization of the half-shadow polarimeter, and rotate it against this direction by about 10° .
- Re-insert the analyzer, and adjust it so that the two halves of the field of view are equally dark (now the analyzer is in zero position).

Carrying out the experiment

- Cautiously pour four spoonfuls of D(+)-saccharose into the plate glass cell (hold a sheet of paper under the prism table), and dissolve the D(+)-saccharose completely by carefully stirring.
- Readjust the analyzer so that the two halves of the field of view are equally dark, and take the new position down.
- Dissolve four additional spoonfuls of D(+)-saccharose several times. In each case determine the position of the analyzer at which the two halves of the field of view are equally dark.

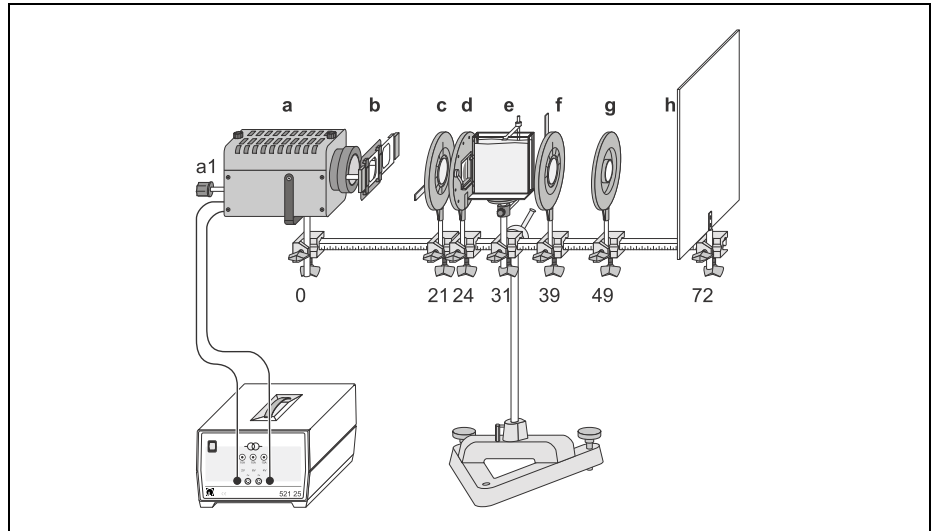
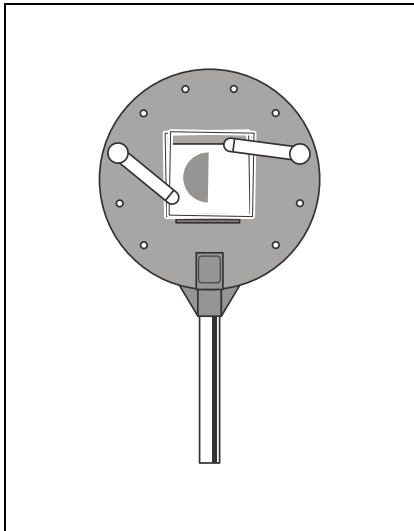


Fig. 2 Half-shadow polarizer P'

Fig. 3 Setup of a half-shadow polarimeter with discrete elements.

- a Halogen lamp housing
- b Light filter (in picture slider)
- c Polarizer
- d Half-shadow polarizer
- e plate glass cell (on prism table)
- f Analyzer
- g Lens
- h Observing screen

Evaluation and results

The angle of rotation of the D(+)-saccharose dissolved in water is obtained from the difference between the positions of the analyzer. It is plotted in Fig. 4 as a function of the number of spoonfuls filled in and thus as a function of the concentration.

Within the measurement accuracy the measured points are on the straight line through the origin drawn in the graph. That means: the angle of rotation is proportional to the concentration of the solution.

Measuring example

- Direction of polarization of the half-shadow polarizer: +75°
- Direction of polarization of the polarizer: +85°
- Zero position of the analyzer: -10°

Table 1:

number of spoonfuls	analyzer position
0	-10°
4	-5°
8	0°
12	4°
16	10°
20	25°

Fig. 4 Angle of rotation of a D(+)-saccharose solution as a function of the concentration

