Polarimeter

Program of SCHMIDT+HAENSCH Polarimeter

- Visual circle polarimeter **for university and school**
- Simple, fully automatic polarimeter **for routine measurements**
- Precise, middle- and high-resolution polarimeter **for highest demands in quality management and research laboratories**
- **Especially for the requirements of sugar analysis:**
  - Polarimeter with an additional wavelength of 882 nm for measuring dark coloured and unclarified samples
  - **Calibration-free polarimeter (SACCHAROMAT®),** applying the unique principle of the quartz wedge compensation

SCHMIDT + HAENSCH
Opto-electronic measuring device since 1864

Product survey

Easy to use, new fully automatic polarimeter UniPol L for routine measurement operations

Scale: Optical rotation, concentration, user defined
Measuring ranges: ± 90°
0 - 99 g/ml
Resolution: 0.01°
0.05 g/ml
Precision: ± 0.01° for angle <45°
± 0.02° for angle >45°
± 0.05 g/ml for angle <45°
± 0.1 g/ml for angle >45°
Temperature measurement: 0 - 99°C
Temperature precision: ± 0.3°C
Wavelengths: 589 nm (optional 546, 578, 663 nm)
Data output: 1 parallel, 1 PS2, 2 seriell RS 232
Dimensions: 650 x 320 x 160 mm
Weight: Approx. 13 kg

L-series

New!

Easy to use, fully automatic polarimeter N-series for routine measurement operations

Continuous measurement without START or RESET.
Direct determination of the rotation angle via mechanical coupling of analyser and optical encoder, remote control.

Measuring range: ± 85° ± 230°Z
Display resolution: 0.01° 0,05°Z
Precision: ± 0.01° ± 0,05°Z
Light source: Halogen lamp
Wavelength: **NHZ8** 589 nm
NNIR 882 nm
NNIRW2 589 nm and 882 nm
NHX 1 wavelength for choice
NW2 2 wavelengths for choice
(in the range between 540 nm and 882 nm)
Measuring tubes: up to 200 mm length, maximum
Display: LCD, 1 line, 16 characters, contrast adjustable
Data output: RS 232 C

N-series

Norms

ICUMSA, O.I.M.L., Australian Standard K 157
The resolution of these polarimeters fully complies with the requirements of the German Pharmacological Book and the European and American Pharmacopeia.

In general

The standard versions of our polarimeter work at 589 nm wavelength. Sugar polarimeter are also available as NIR (882 nm) or NIRW2 (589 and 882 nm) models. The advantage of the NIR instruments being that samples, if thoroughly filtered, do not have to be clarified, because at NIR wavelengths, highly absorbent samples may also be measured easily. In order to be able to control the stability of the measured values, the optical density will automatically be on display. (L-, M-series and higher)

Combination of
Polarimeter + Refractometer = Purity analyzer
Please ask for special leaflet

Product survey

Precise and high-resolution polarimeter for highest demands in quality and research laboratories.
The M- and H-series as well as the SACCHAROMAT® are part of a modular system. Their common specifications are:

Measuring tubes: Up to a max. length of 200 mm
Temperature: Automatic temperature control available
Display: Alphanum. LCD, 8 lines, 30 characters contrast adjustable, graphical option
Data output: RS 232 C (other outputs upon request)
Mains connections: 110/240 V, 50/60 Hz
Dimensions: 735 x 425 x 200 mm
Weight: Approx. 28 kg

Continuous measurement without START or RESET.
Direct determination of the rotation angle via mechanical coupling of analyzer and optical encoder, remote option.

M-series

M-series

Measuring range: ± 85° ± 230°Z
Display resolution: 0.002° 0.01°Z
Precision: ± 0.005° ± 0.02°Z
Light source: Halogen lamp
Wavelength:
MHZ8 589 nm
NIR 882 nm
NIRW2 589 nm and 882 nm
MHX 1 wavelength for choice
MW2 2 wavelengths for choice
(in the range between 405 nm and 589 nm or 540 nm and 882 nm)

H-series

H-series

Measuring range: ± 85°
Display resolution: 0.001°
Precision: ± 0.002°
Light source: Halogen- or spectral lamp
Wavelength:
HH8 589 nm
HHX 1 wavelength for choice
HHW5/
HNQW5 5 wavelengths for choice

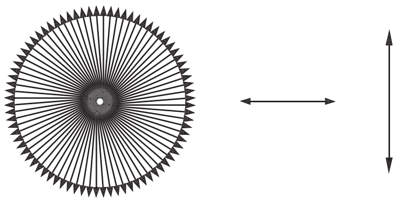
SACCHAROMAT®-serie

SACCHAROMAT® - Sugar polarimeter applying the principle of quartz wedge compensation

Measuring range: -35°Z to +105°Z
Display resolution: 0.01°Z
Precision: ± 0.02°Z
Light source: Halogen lamp
Wavelength:
Z 587 nm
NIR 882 nm
NIRW2 587 nm and 882 nm

Technical basics

Classical physics teaches that light consists of electromagnetic waves, which's vibrations are transverse to the direction of propagation. Polarized light is light, which's vibration pattern exhibits preference. If natural light passes through a so called polarizing filter, most of it's other vibrating directions will be filtered out, leaving only one specific direction. If this light is oscillating then in only one direction, it is called "linearly polarized".



Natural light   Polarized light

There is a great number of organic and inorganic substances being optically active in their crystalline, liquid or dissolved state. That means, these substances are able to rotate the direction of oscillation of polarized light around a determined angle.
Typical optically active substances contain at least one asymmetric atom in their molecule structure. Such atoms are C(arbon), S(ulphur), P(hosphor), Si(lica) and few others. This asymmetry leads to the formation of two isomers (+;-) which both cause an optical rotation, but in different directions. Some well known optical substances are tartaric acid, lactic acid, benzoic acid and derivates, amino acids, proteins and of course sugars.
If an optically active substance (f.i. sugar) is dissolved in an optically inactive liquid (as water for instance), the degrees of angle rotation, depend - amongst others - on the concentration of the solution. This angle of rotation is absolutely determined by a polarimeter with highest precision.

General structure of a polarimeter

The principle of the polarimeter is accomplished if a dissolved optically active substance is introduced between two polarizing filters, crossed at 90°.
The intensity of the light on the detector behind the second polarizing filter varies as a function of the angular position of these two filters.
Optical rotation in general means that the polarization of the direction of light will be rotated for a certain angle when penetrating an optically active substance.

A simple polarimeter contains at least the following parts:

Light source   Polarising filter   Sample tube   Polarising filter   Detector

At point zero, polarizer and analyzer are set in an angle of 90° towards each other, which means that no light reaches the detector (0% transmission). As soon as an optically active substance is introduced into the sample room, the transmission will be rising in consequence of the plane of polarization. To measure the angle of the rotation, the analyzer is rotated up to a point where the transmission of the detector is again at a minimum. Optical rotation is measured in degrees of angle; this kind of instruments are thus called **circle polarimeters**.
In order to determine the exact compensation position, SCHMIDT+HAENSCH uses **faraday modulation** as an electronic enhancement. Without mechanical transmission by a V-belt or gear being necessary, we applies a **direct coupling of optical encoder and analyzer** in all measuring instruments. That is how a high accuracy throughout the entire measuring range is achieved. Additionally, these principles guarantee for short measuring times and no mechanic wear. Consequently, highest sensitivity and fastest compensation time over the entire measuring range is archieved. The continuous measurement is also allowing monitoring of muto-rotation.

Dependency of the optical rotation

1. Nature of the sample
2. Concentration of the optical active components
3. Wavelength of the light
4. Temperature of the sample
5. Optical path length (length of the measuring tube)

The corresponding formula was found by the French physician Jean B. Biot and described as following in the "Biot's law":

$$C = \frac{a}{[\alpha]} \cdot \frac{10000}{L}$$

c = concentration in g/cm^3
L = tube length in mm
[α] = specific rotation (depending of temperature and wavelength)
a = measured rotation in angular degrees

Example:

26 g of sucrose dissolved in pure water and filled up to a volume of 100 cm^3 has an optical rotation of 34.626° ang $\pm$ 0.001° in a 200 mm sample tube at 20°C under normal pressure (1013 hPa) at a wavelength of 589.44 nm. This solution is called **normal sugar solution**. It was used to calibrate and standardize polarimetric methods and instruments and is also the origin of the **International Sugar Scale (ISS)** defined by ICUMSA. The rotation of 34.626° ang corresponds to a concentration of 26 g saccharose respectively 100.00°Z (sugar). ISS is linear, that means a rotation of 17.313° ang corresponds to 50.00°Z (13 g/100 cm^3).
Sugar solutions are not very stable and have to be renewed regularly. Checking a polarimeter by a quartz plate is a much more reliable method. In 1811 already the French physician F. Arago discovered the polarizing qualities and optical activity of natural quartz. The rotation depends on the thickness of the quartz, on the wavelength of the light and, most important, it's wavelength dependency is almost the same as that of a sucrose solution. Quartz control plates are used today

as a standard for the calibration of polarimeters.

The influence of the wavelength – optical rotatory dispersion (ORD)

In the polarimeter used in the sugar industry four different wavelengths are being applied. At these wavelengths and at a temperature of 20°C, the following specific rotations [α] and angular rotations of a "standard sugar solution" in a 200 mm tube are being measured:

Description	Wavelength	[α]	α
Mercury green	546.23 nm	78.4178°	40.777°
Sodium, yellow	589.44 nm	66.5885°	34.626°
HeNe-Laser	632.99 nm	57.2144°	29.751°
NIR	882.60 nm	28.5462°	14.844°

For more detailed definitions of the International Sugar Scale, please consult "Specification and Standard SPS-1 (1998): Polarimetry and the International Sugar Scale" in the ICUMSA methods book.
The angles measured at the four wavelengths clearly show a significant dependency of the wavelength of the light on the optical rotation. Changing the wavelength for 0.03 nm leads to a shift of the value of optical rotation for 0.01% (that means a change of 0.035 angular degrees for a "standard sugar solution" measured at 589 nm). Thus in polarimetry only light sources with a very narrow spectrum are being applied. Typically, this is achieved today with a halogen lamp and an interference filter with a narrow spectral half width.

The quartz wedge principle

Quartz has an optical rotation dispersion (ORD) almost identical to that of a sucrose solution. This fact is exploited as a unique compensation mechanism using a quartz wegde in SCHMIDT+HAENSCH's **SACCHAROMAT®**. When a sample is introduced, the quartz wedge slides into the optical path (equivalent to changing the thickness of the quartz) to a point where the optical rotation of the sample is exactly compensated. The position of the wedge is then determined by a **linear encoder**, giving rise to a very precise measurement. The principle of quartz wedge compensation is unique and is unrivalled today. With its high precision and high reliability it is used through out the sugar industry.

As the quartz and the sample react in an identical way to small shifts of the wavelength, these shifts are beeing automatically compensated and the effect becomes irrelevant. This ensures highest wavelength stability without the necessity of recalibration over the lifetime of the instrument.
The quartz wedge principle also results in higher optical light input allowing very dark solutions to be easily measured.

- Little influence of wavelength shifts
- Long time stability of measured values without calibration being necessary

Temperature effects

The measured optical rotation values depend on the temperature. The rotation of quartz for example raises with higher temperatures:

Rotation (T) = rotation (20.0°C) x (1.0 + 0.000144 x (T-20.0))

A quartz plate, showing a value of 40.000° ang at a temperature of 20°C, will give a value of 40.006° ang at 21°C and the value will even raise to 40.029° ang at 25°C already.

In contrast, the rotation of a sucrose solution will decrease with rising temperature:

Rotation (T) = rotation (20.0°C) x (1.0 - 0.000471 x (T-20.0))

A solution indicating 40.000° ang at a temperature of 20°C, will indicate only 39.981° ang at 21°C and just 39.906° ang at 25°C.

Please consider, that there are three temperature effects on diluted samples:

1. The flask, which is applied to fill up the 100 cm^3 is calibrated for 20°C.
2. The length of the tube is valid for 20°C.
3. The optical activity of the sample is influenced by the temperature.

The formula given above only counts for the third effect. To compensate all temperature effects, the SACCHAROMAT's® quartz wedges are equipped with a temperature sensor that is also optionally available for the tubes.

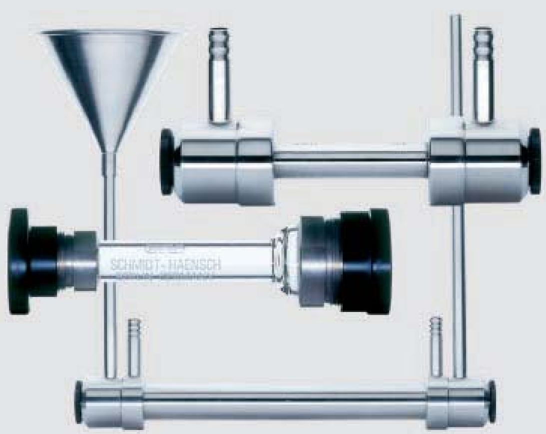
SCHMIDT+HAENSCH guarantees for the precision of it's Polarimeters only as long as original SCHMIDT+HAENSCH measuring tubes are used. These tubes offer a certified tolerance in length (0.02 mm for a 200 mm tube, 0.01 mm for a 100 mm tube.)

To measure unclarified samples, SCHMIDT+HAENSCH recommends the system **AutoFilt®**. This semi automatic filtration system filtrates an industrial sugar solution to a turbidity-free state within 30 sec. maximum.

Flow-through tube with T-sensor

Visual circle polarimeter

Quartz control plate with integrated temperature sensor



Variety of polarimetric tubes for your application, please ask for special leaflet

Product survey

Visual circle polarimeter for universities and schools
Visual half-shadow polarimeter with an circular scale of ±180° divided into full degrees. Together with the Vernier scale rotations can be measured to an accuracy of 0.1° and with a little practice they can be estimated to an accuracy of 0.05°.

Measuring range: ± 180°
Resolution: 0.1°
Precision: ± 0.1°
Light source: Halogen- or spectral lamp
Wavelength: 589 nm or 546 nm
Measuring tubes: With bubble trap or funnel, max. length 200 mm
Mains adapter: 110/240 V, 50/60 Hz

Polarimeter applications

A polarimeter has a wide field of applications in the quality control of food, chemical and pharmaceutical industries. The most important application is the analysis of sugar (measurement using the international unit of the sugar scale °Z).

Food industries
Quality control of original, intermediate- and final products, determination of concentration and purity control. Sugar industry, dairy industry, wine industry, beverage industry, fruit industry, food additives

Pharmaceutical industry
Purity control and determination of concentration of substances according to the requirements of the European, American and other national Pharmacopoeias.

Medicine
Analysis of sugar and albumin in urine, hormon research, enzymology and toxical research

Cosmetic industries
Control of purity and identity of optically active essential oils and essences.

Chemical industries
Purity control and determination of concentration, organic fluids and inorganic ions

Chemical research
Analysis of optically active compounds and structure analysis, determination of configuration changes of macromolecule in solutions

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Opto-electronic measuring device since 1864