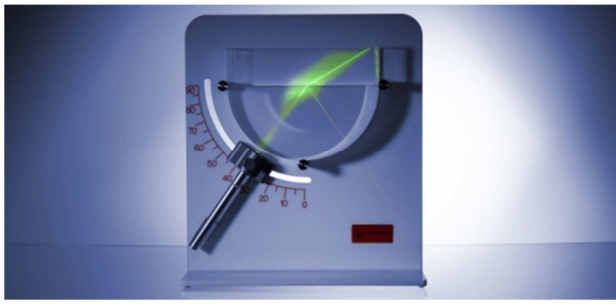
What is refractometry?

The didactic refractometer from Anton Paar



A refractometer is the instrument used to measure the refractive index of materials.

What is refractive index?

The refractive index of a medium is a measure of how much the speed of light is reduced inside the medium related to the speed of light in vacuum.

The higher the medium's optical density the lower is the speed of light inside the medium.

Light refraction and total reflection

If light is passing the interface of two media with different optical densities, and therefore different refractive indices, it will be refracted and/or reflected at the interface. Depending on the angle of incidence a part of the light will be refracted in the media while another part will be reflected [Fig.1].

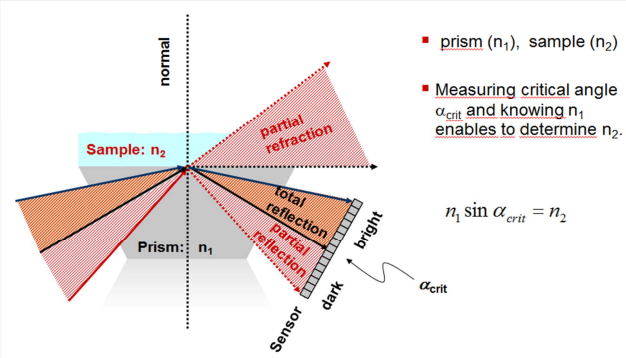


Fig. 1: Partial and total reflection of light at the boundary surface

The angle of incidence is always defined relative to the perpendicular. With a small angle of incidence - relative to the perpendicular of the interface - the light in medium 2 (sample) will be refracted and in medium 1 (prism) partially reflected.

The bigger the angle of incidence of the light beam the more the refracted light beam approaches the interface between both media until finally the refracted beam is exactly in the interface. This angle of incidence is called *the critical angle of total reflection.* If the angle of incidence increases further, all the light will be reflected.

You can notice this if you are standing at a calm lake [Fig. 2].

Fig. 2: Partial und total reflection onto the surface of the water

If you are looking onto the lake with a big angle of incidence to the perpendicular of the surface of water, the opposite lakefront is reflected in the surface of the water (the light will be reflected on the surface of the water). In contrast if you are looking onto the lake with a small angle of incidence to the perpendicular of the surface of the water you can see the bottom of the lake if the water is clear. By the way: As the light will be additionally reflected through the crossover of water/air, objects such as stones and fish are not actually in the place in the water, where they seem to be.

It is possible to determine the refractive index of materials by measurement of the critical angle of total reflection. As the refractive index is a physical

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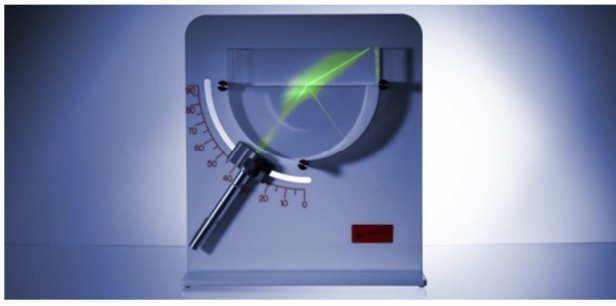

constant of a particular material - meaning a particular material has always the same refractive index - the measurement of refractive index can be used for characterization of material and for material checks.

The refractive index of binary solutions changes with the amount of solute. Therefore, the measurement of refractive index can be also used for determining of the concentration of binary solutions.

Multicomponent mixes have a defined refractive index for an exactly defined mixing ratio. For this reason the measurement of refractive index is used for quality control of multicomponent mixes.

Measuring principle of refractometers

The measuring principle of the didactic refractometer - which is also used in modern automatic refractometers - is based on the determination of the angle of total reflection, see Fig. 1.

If the refractive index n_1 of a medium and the critical angle α_{crit} are known they can be used to determine the unknown refractive index n_2 of a second medium. The relationship is explained with Snell's law:

$$\frac{\sin \alpha_1}{\sin \alpha_2} = \frac{n_2}{n_1}$$

α_1 = angle of incidence of light

α_2 = angle of the refracted light beam

n_1 = refractive index medium 1 (prism)

n_2 = refractive index medium 2 (sample)

Is $\alpha_1 = \alpha_{crit}$ then $\alpha_2 = 90°$ [Fig. 1].

With sinus (90°) = 1 Snell's law results in:

$$\sin \alpha_{crit} = \frac{n_2}{n_1}$$

If the refractive index n_1 of the medium 1 (prism) is known, the refractive index of the sample (medium 2) can be determined through the measurement of $\alpha_{crit.}$.

The prism of the didactic refractometer is made of acrylic glass having a refractive index n_1 of 1.4947 at the wavelength 532 nm of the green laser pointer.

With the refractometer model a rough determination of the refractive index of liquids can be done. For this the refractometer model offers a cell above the prism which can be filled with different liquids.

The refractometer model consists of a moveable light source (laser pointer) which allows illumination of the interface between the prism and sample under different angles of incidences.

With the didactic refractometer model the phenomenon of light refraction can be explained easily. Furthermore, it is possible to make easy measurements of the refractive index of liquids. The cell above the prism can be filled with a substance whose refractive index should be determined. Afterwards the critical angle of total reflection is adjusted by changing the angle of incidence of light. Once the critical angle is found a reading of the angle of incidence can be taken from the engraved scale. Using Snell's law the refractive index of the sample can be calculated. In this way the refractive indices of different solutions can be estimated, which allows e.g. determination of the concentration of these solutions.

As the refractive index depends on the temperature and the wavelength of light the received results can only be used for qualitative measurements and for the understanding of reflection of light and the refractive index.

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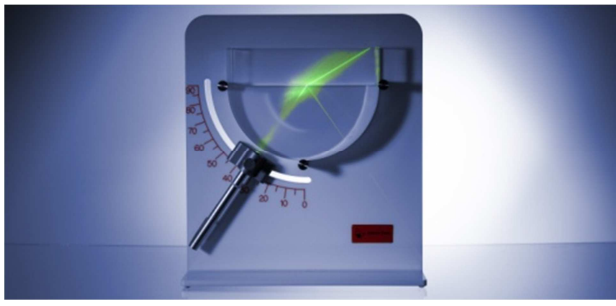

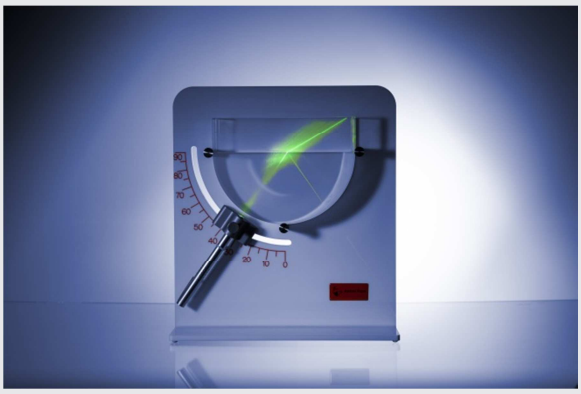

Technical Specifications

Dimensions:

Length: 13.3 cm
Width: 32.0 cm
Height: 35.0 cm
Weight: approx. 2.5 kg, without sample

A laser pointer with the wavelength of light of 532 nm is included in the delivery.

Tip:

The cell of the prism can be filled with different liquids to measure the refractive index. Without liquid in the cell the refractive index of air can be determined.

The acrylic glass of the prism is not resistant to acids and organic solvents. Therefore, aggressive solutions should be avoided.

For further information please contact your Anton Paar representative.

Order no.: 130173