

Abbe Refractometer



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I Instrument Application

The Abbe refractometer measures the refractive index n_D and mean dispersion $n_F - n_C$ of transparent or semi-transparent liquids and solids, mainly liquids. When a constant-temperature bath is connected, the refractive index n_D can be measured at temperatures from 0 to 70 °C.

Refractive index and mean dispersion are important optical constants of a substance. They can be used to understand optical properties, purity, concentration, and dispersion. The instrument can also measure the mass percentage of sugar in a sucrose solution from 0 to 95%, corresponding to a refractive-index range of 1.333 to 1.531. It is therefore widely used in petroleum, oils and fats, pharmaceutical, paint, food, household chemical, sugar, geological survey, educational, and research laboratories.

II Instrument Specifications

Specification	Value
Measuring range n_D	1.3000 to 1.7000
Measurement accuracy n_D	± 0.0002
Instrument mass	2.6 kg
Overall dimensions	100 × 200 × 240 mm

III Brief Description of the Working Principle

The basic principle of the refractometer is the law of refraction. If n_1 and n_2 are the refractive indices of the two media on either side of an interface, α_1 is the angle of incidence, and α_2 is the angle of refraction, then:

$$n_1 \sin \alpha_1 = n_2 \sin \alpha_2$$

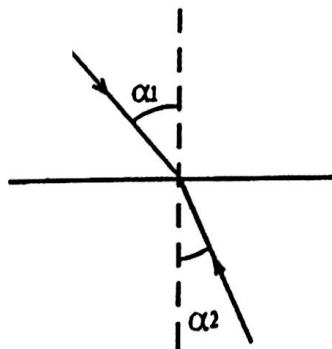


Figure 1
3

III Brief Description of the Working Principle

When light passes from an optically denser medium into an optically rarer medium, the angle of incidence is smaller than the angle of refraction. By increasing the angle of incidence, the angle of refraction can reach 90°. The corresponding angle of incidence is called the critical angle. This instrument determines refractive index by measuring the critical angle.

In Figure 2, rays entering surface AB at different angles are refracted toward the same limiting direction. When the emergent rays are observed through a telescope, the field is divided into a bright part and a dark part, as shown in Figure 3. The clear boundary between them corresponds to the position of the critical angle.

In Figure 2, ABCD is a refracting prism with refractive index n_2 , and the measured sample is placed above surface AB.

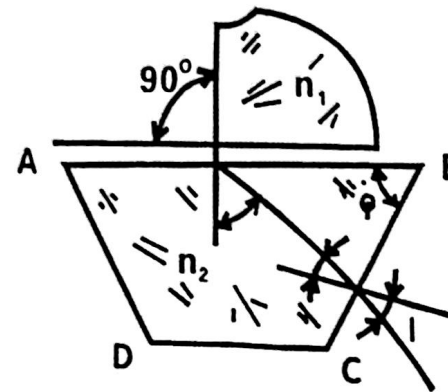


Figure 2

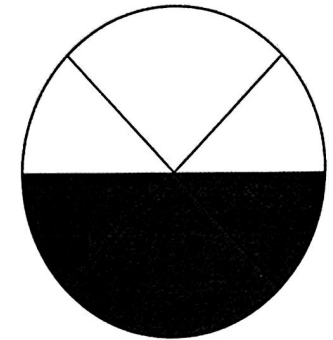


Figure 3

IV Instrument Structure

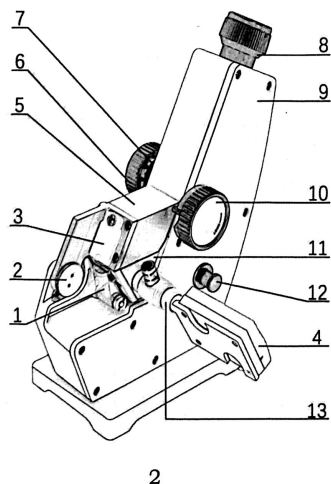


Figure 4

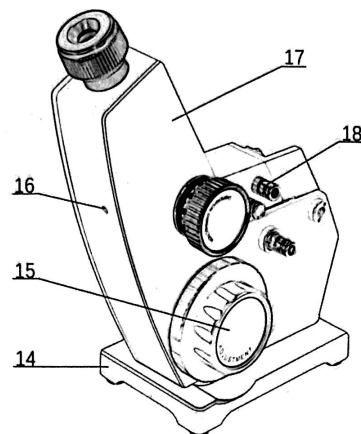


Figure 5

Structural Parts Refer to Figures 4 and 5

The base (14) supports the instrument, and the housing (17) is fixed to it. Except for the prism assembly and eyepiece, all optical components and the main mechanism are enclosed within the housing. The prism assembly is fixed to the housing and consists of the illuminating prism, refracting prism, and their holders. Both prisms are bonded into their holders with a special adhesive.

Part (5) is the illuminating-prism holder and part (11) is the refracting-prism holder. The two holders are connected by hinge shaft (2). The illuminating prism can be opened and closed. When the two prism holders are brought together and locked with handwheel (10), a uniform gap remains between the two prisms; the liquid sample must fill this gap. Part (3) is the light shield. Part (18) consists of four constant-temperature bath connectors. Part (4) is the thermometer, and part (13) is the thermometer socket; rubber tubes may be used to connect the instrument to a constant-temperature bath.

Part (1) is the reflector, part (8) the eyepiece, part (9) the cover plate, part (15) the refractive-index scale adjustment handwheel, part (6) the dispersion adjustment handwheel, part (7) the dispersion-value scale ring, and part (12) the scale-illuminating condenser lens.

V Use and Operating Method

1 Preparation

(1) Before measurement, first calibrate the reading with a standard sample. Place 1 to 2 drops of bromonaphthalene on the polished surface of the refracting prism, then place the polished surface of the standard sample against it. When the reading field indicates the certified value of the standard sample, observe whether the bright-dark boundary in the telescope is centered on the crosshair. If it is displaced, use a screwdriver to turn the screw in small hole (16) shown in Figure 5. This tilts the objective lens and moves the boundary image to the center of the crosshair. Repeat the observation and correction until the initial reading error, including the operator's alignment error, is minimized. After calibration, do not move this adjustment during subsequent measurements.

If the refractive-index reading is doubtful during routine work, use the standard sample and the method above to check for an initial error and recalibrate if necessary.

(2) Before every measurement and during reading calibration, clean the matte surface of the illuminating prism, the polished surface of the refracting prism, and the polished surface of the standard sample. Wipe them gently with degreased cotton moistened with a 1:4 mixture of anhydrous alcohol and ether. No foreign material may remain, because it can reduce image clarity and measurement accuracy.

2 Measurement

(1) Transparent or semi-transparent liquid. Use a clean dropper to place the liquid sample on the refracting-prism surface. Close the illuminating prism and lock it with handwheel (10). The liquid layer must be uniform, fill the viewing field, and contain no bubbles. Open light shield (3), close reflector (1), and adjust the eyepiece until the crosshair is sharp. Turn handwheel (15) to locate the bright-dark boundary in the eyepiece field. Then turn handwheel (6) until the boundary has no color. Fine-adjust handwheel (15) until the boundary is centered on the crosshair, and turn scale-illuminating condenser lens (12) as necessary. The reading shown in the lower part of the eyepiece field is the refractive index of the measured liquid.

V Use and Operating Method

2 Measurement (continued)

- (2) Transparent solid. The measured object must have a flat, polished surface. Open the illuminating prism, place 1 to 2 drops of bromonaphthalene on the polished surface of the refracting prism, clean the polished surface of the object, and place it against the prism so that good contact is obtained. Locate the boundary in the eyepiece field; aiming and reading are performed as described above.
- (3) Semi-transparent solid. The measured semi-transparent solid must also have a flat, polished surface. During measurement, use bromonaphthalene to bond the polished surface of the solid to the refracting prism. Open reflector (1), adjust its angle, and use reflected light for the measurement. The remaining operating method is the same as above.
- (4) Sugar concentration in sucrose solution. The operation is the same as for measuring the refractive index of a liquid. Read the value directly from the upper part of the field; it is the mass percentage of sugar in the sucrose solution.
- (5) Mean dispersion. The basic operating method is the same as for measuring refractive index. Turn dispersion adjustment handwheel (6) in two different directions until the bright-dark boundary in the field is colorless. Record the scale value Z indicated on dispersion-value scale ring (7) for each approach and take the average. Also record the refractive index n_D . From the Abbe refractometer dispersion table, find values A and B in the same row corresponding to n_D ; if n_D lies between two tabulated values, obtain them by interpolation. Then use Z to find the corresponding σ value in the table. When $Z > 30$, use a negative value; when $Z < 30$, use a positive value. Substitute the resulting A , B , and σ values into the dispersion formula to calculate the mean dispersion.
- (6) Refractive index at different temperatures. Insert the thermometer into thermometer socket (13), connect the tubing from a constant-temperature bath, set the bath to the required measurement temperature, and circulate the water. After the temperature has remained stable for ten minutes, carry out the measurement.

VI Maintenance

To maintain measurement accuracy and prevent damage, observe the following points:

- (1) Place the instrument in a dry, well-ventilated room so that moisture does not cause mold on the optical components.
- (2) After testing a corrosive liquid, clean the optical components, metal parts, and painted surfaces promptly to prevent corrosion. Clean the instrument after every use. When the instrument is stored in its wooden case, place a desiccant such as indicating silica gel in the case to absorb moisture.
- (3) The measured sample must not contain hard impurities. When a solid sample is measured, prevent scratching or indentation of the refracting-prism surface.
- (4) Keep the instrument clean. Do not touch optical components with oily or sweaty hands. Remove dust from an optical surface gently with high-grade chamois leather or long-fiber degreased cotton, then blow it away with an air bulb. If an optical surface is stained with grease, wipe it promptly with the alcohol-ether mixture.
- (5) Protect the instrument from strong vibration and impact to prevent damage to the optical components and loss of accuracy.