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ABBE REFRACTOMETER

About

Abbe refractometer used to find refractive index of the given liquid samples and find Molar refraction and specific refraction.

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Abbe Refractometer

1 Objective

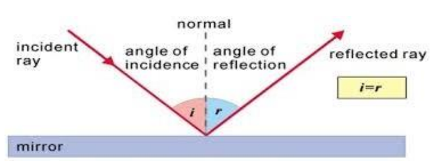
- To find the refractive index of the given liquid samples and find Molarrefraction and specific refraction.

2 Principles

The Abbe refractometer, named after its inventor Ernst Abbe (1840-1905), was the first laboratory instrument for precisely determining the refractive index of liquids. The measuring principle of an Abbe refractometer is based on the principle of total reflection. Abbe refractometers are used for measuring liquids. The reference media glasses (prisms) can be selected with high refractive indices. A mirror reflects the light from a radiation source and hits a double prism. A few drops of the sample are placed between this so-called Abbe double prism. The incident light beams pass through the double prism and sample only if their angles of incidence at the interface are less than the critical angle of total reflection. A microscope and a mirror with a suitable mechanism areused to determine the light / dark boundary line (shadow line).

Reflection of light

Reflection of Light is the process of sending back the **light** rays that fall on an object's surface. The image formed due to the **reflection** of anobject on a plane mirror at different places



Reflection is the change in the direction of wave passing from one medium to another medium. Some part of the rays reflects at the same angle (α) and some refract at different angles (β)

Snell's Law

The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, for the light of a given color and the given pair of media. The refractive angle is determined by Snell's law

$$n_1 \, Sin\,\alpha = n_r \, Sin\beta$$

n_1 is the refractive index of medium 1

n_r is the refractive index of medium 2

$$\frac{\text{Sin i}}{Sin\,r} = n = \frac{velocity\ of\ light\ in\ 1st\ medium}{velocity\ of\ light\ in\ 2nd\ medium}$$

Abbe's Refractometer

The Abbe instrument is the most convenient and widely used refractometer, Fig(1) shows a schematic diagram of its optical system. The sample is contained as a thin layer (~0.1mm) between two prisms. The upper prism is firmly mounted on a bearing that allows its rotation using the side arm shown in dotted lines. The lower prism is hinged to the upper to permit separation for cleaning and for the introduction of the sample. The lower prism face is rough-ground: when light is reflected into theprism, this surface effectively becomes the source for an infinite number of rays thatpass through the sample at all angles. The radiation is refracted at the interface of the sample and the smooth-ground face of the upper prism. After this, it passes into the fixed telescope. Two Amici prisms that can be rotated concerning another serve to collect the divergent critical angle rays of different colors into a single whitebeam, that corresponds in path to that of the sodium D ray. The eyepiece of the telescope is provided with crosshairs: in making a measurement, the prism angle is changed until the light-dark interface just coincides with the crosshairs. The positionof the prism is then established from the fixed scale (which normally graduates inunits of n_D). Thermosetting is accomplished by the circulation of water through the jackets surrounding the prism. The Abbe refractometer is very popular and owes its popularity to its convenience, its wide range (n_D = 1.3 to 1.7), and the minimal sample needed. The accuracyof the instrument is about ±0.0002; its precision is half this figure. The most seriouserror in the Abbe instrument is caused by the fact that the near glazing rays are cutoff by the arrangement of to prisms; the boundary is thus less sharp than is desirable. A *precision* Abbe refractometer, that diminishes the uncertainties of the ordinary instrument by a factor of about three, is also available; the improvement in accuracyis obtained by replacing the compensator with a monochromatic source and by using larger and more precise prism mounts. The former provides a much sharper critical boundary, and the latter allows a more accurate determination of the prism position.

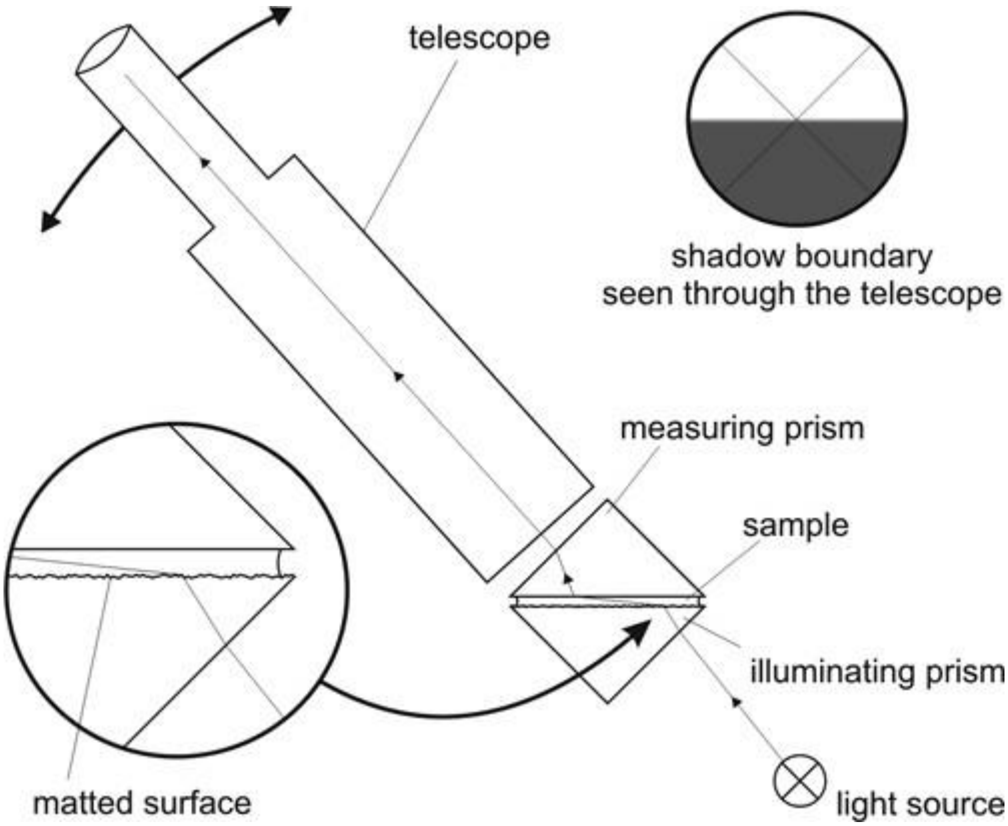


Figure 1: Light entering the illuminating prism produces dark and bright regions in the field of view

Measurement of refractive index

The refractive index of a substance is ordinarily determined by measuring the change in direction of collimated radiation as it passes from one medium to another.

$$\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\sin\theta_1}{\sin\theta_2} \qquad (1)$$

Where v_1 is the velocity of propagation in the less dense medium M_1 and v_2 is the velocity in medium M_2; n_1 and n_2 are the corresponding refractive indices and θ_1 and θ_2 are the angles of incidence and refraction, respectively Fig 2.

When M_1 is a vacuum, n_1 is unity because v_1 becomes equal to c in equation (1). Thus,

$$n_2 = n_{vac} = \frac{c}{v_2} = \frac{\sin\theta_1}{\sin\theta_2} \tag{2}$$

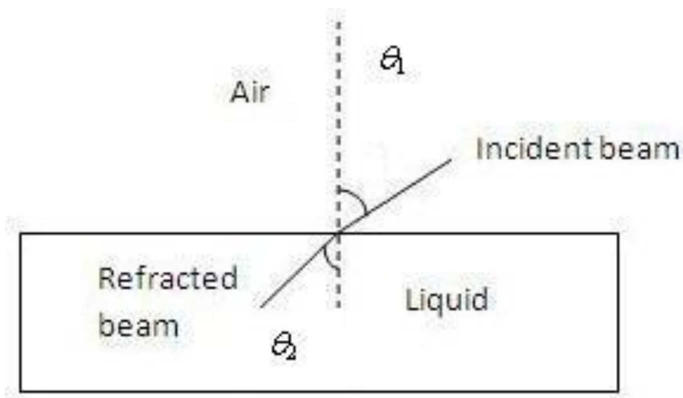


Fig. 2

Where n_{vac} is the absolute refractive index of M_2. Thus n_{vac} can be obtained by measuring the two angles θ_1 and θ_2.

Factors affecting refractive index

Various factors that affect refractive index measurement are

1. Temperature

Temperature influences the refractive index of a medium primarily because of the accompanying change in density. For many liquids, the temperature coefficient lies in the range of -4 to -6 $\times 10^{-4}$ deg^{-1}. Water is an important exception, with a coefficient of about -1 x10^{-4}deg^{-1}.

2. Wavelength of light used

The refractive index of a transparent medium gradually decreases with increasing wavelength; this effect is referred to as normal dispersion. In the vicinity of absorption bands, rapid changes in refractive index occur; here the dispersion is anomalous.

3. Pressure

The refractive index of a substance increases with pressure because of the accompanying rise in density. The effect is most pronounced in gases, where the change in n amounts to about 3x10^{-4} per atmosphere; the figure is less by a factor of 10 for liquids, and it is yet smaller for solids.

3 Apparatus

Abbe's refractometer.

4 Experimental Steps

1. Clean the surface of the prism first with alcohol and then with acetone using cottonand allow it to dry.
2. Using a dropper put 2-3 drops of the given liquid b/w prisms and press them together
3. Allow the light to fall on the mirror.
4. Adjust the mirror to reflect maximum light into the prism box
5. Rotate the prism box by moving the lever until the boundary b/w shaded and brightparts appear in the field of view.
6. If a band of colors appears in the light shade boundary make it sharp by rotatingthe compensator.
7. Adjust the lever so that the light shade boundary passes exactly through the centerof cross wire
8. Read the refractive index directly on the scale

Figure 2. Refractive index values as read on the scale

9. Take 3 sets of readings and find the average of all the readings.
10. The refractive index of water is 1.3333

OBSERVATIONS:

Room temp. =……………………… degrees

Sr.#	Liquid	Refractive index

Specific refraction, $R = (n^2 - 1) / (n^2 + 2) \times 1/d$

Molar refraction, $R_M = R \times M$ (molecular mass of liquid)

The refractive index of some common liquid

Variation of refractive index with wavelength

To study the effect of the wavelength of light on refractive index, we have used blue(420nm), yellow (590nm), and red (630nm) LED lights obtained from a solid-state lamp. For castor oil, the value of the refractive index obtained is tabulated in Table 2.

Table-2

Liquid	Refractive index		
	420 nm (Blue)	630nm (Red)	590 nm (Yellow)
Castor oil	1.475	1.476	1.475

Refractive index of castor oil for blue, yellow and red lights

It may be noted that the values of refractive indices obtained for different colors of light are the same, indicating the inability of the model to differentiate wavelengths.

Table-1

Liquid	Refractive index	
	Expt.	Standard
Castor oil	1.474	1.4470 -1.4810
Milk	1.424	1.3500-1.4500
Water	1.325	1.3330
Honey	1.472	1.4800-1.5000
Sunflower oil	1.458	1.4600
Sugar syrup (50%)	1.448	1.4200
Dettol cream	1.359	NA

Refractive index of some common liquids