REFRACTOMETRY

Presented By:
Dr. Joohee Pradhan

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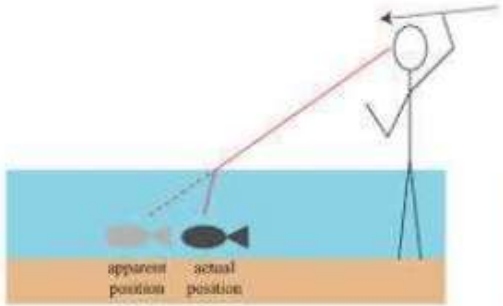
REFRACTOMETRY

- Refractometry is the method of measuring substances refractive index (one of their fundamental physical properties) for example, assess their composition or purity.

- A refractometer is the instrument used to measure refractive index ("RI"). Although refractometers are best known for measuring liquids, for quick evaluation of concentration of dissolved substances.

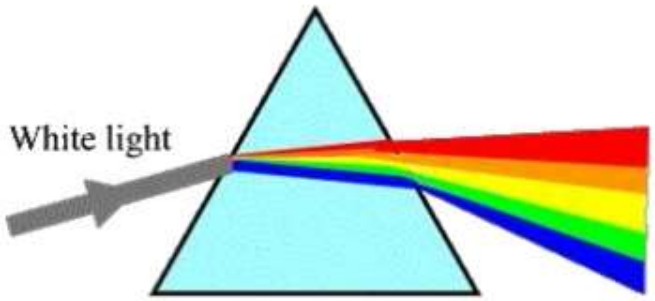
- Measurement of refractive index of unknown substance. measure substances dissolved in water and certain oils.

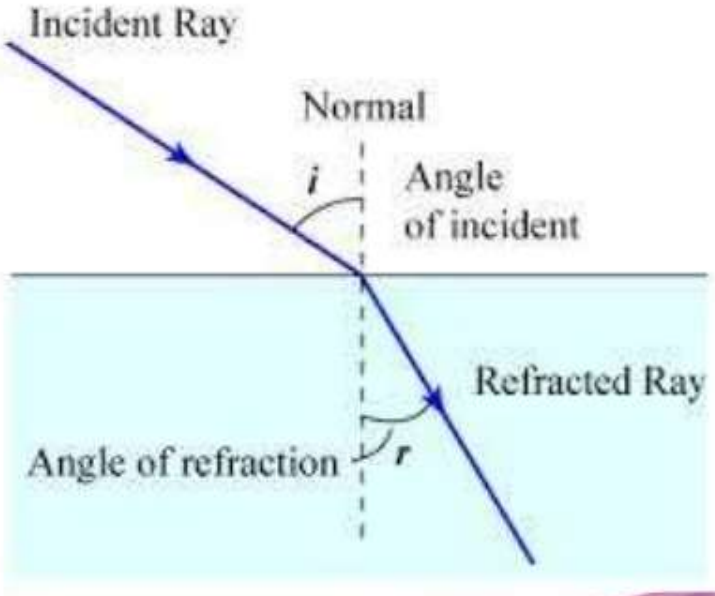


PRINCIPLE

Measurement of RI of unknown substance by measuring angle of refraction made when the substance is brought into contact with the medium (prism) of a known refractive index

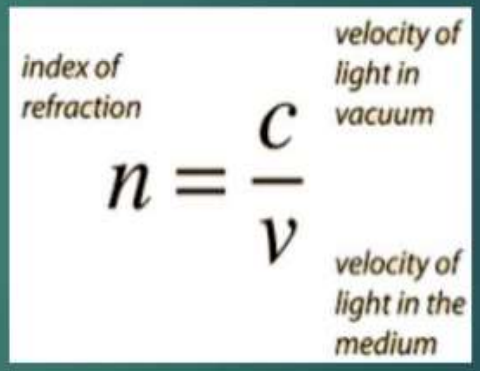
Refraction through a prism





Refractive Index

- This is a measure of how much light slows down when it goes into a new medium.
- Symbol n
- n (vacuum) = 1



$$n\ (\text{medium}) = \frac{c\ (\text{speed of light in vacuum})}{v\ (\text{speed of light in medium})}$$

EXAMPLES

Liquid	Refractive Index
water	1.33
acetone	1.36
glycerin	1.47
benzene	1.50
silicone oil	1.52
sodium chloride	1.54

REFRACTIVE INDEX

- The ratio of the speed of light in a vacuum to the speed of light in another substance is defined as the refractive index for the substance

- The speed of light in a vacuum is always the same, but when light moves through any other medium it travels more slowly since it is constantly being absorbed and re-emitted by the atoms in the material.

- Samples with different refractive indexes will produce different angles of refraction and this will be reflected in a change in the position of the borderline between the light and dark regions.

REFRACTIVE INDEX (CONTI...)

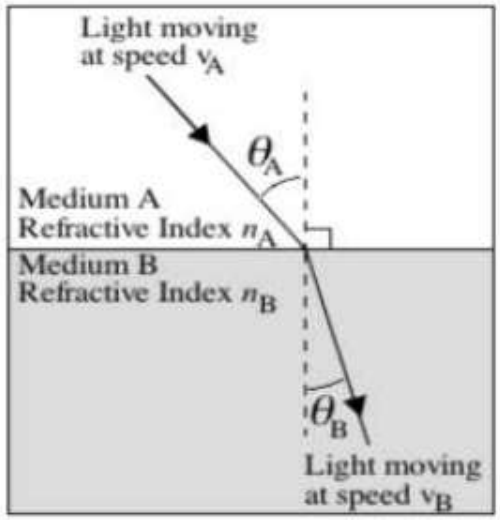
- **Absolute index of refraction (N)** is the relation of speed widening of light in the vacuum to its speed in the present medium

- **Relative index of refraction (n)** is the relation of speed widening of light in the air to its speed in the present medium

- In the case shown, the speed of light in medium A is greater than the speed of light in medium B.

- The relationship between light's speed in the two mediums (vA and vB), the angles of incidence (¯A) and refraction (⊓B) and the refractive indexes of the two mediums (nA and nB) is shown:

$$\text{refractive index } (n) \text{ of substance} = \frac{\text{speed of light in a vacuum}}{\text{speed of light in substance}}$$



$$\frac{v_A}{v_B} = \frac{\sin\theta_A}{\sin\theta_B} = \frac{n_B}{n_A}$$

$$\frac{n_D}{n_{unknown}} = \frac{\sin i}{\sin r}$$

FACTORS INFLUENCING RERFACTIVE INDEX

The two factors which affect the value of the refractive index are:

- **Temperature**
  - Refractive index values are usually determined at standard temperature.
  - A higher temperature means the liquid becomes less dense and less viscous, causing light to travel faster in the medium. This results in a smaller value for the refractive index due to a smaller ratio.
  - A lower temperature means the liquid becomes denser and has a higher viscosity, causing light to travel slower in the medium. This results in a larger value for the refractive index due to a larger ratio.
  - Refractometers usually have a means of temperature regulation.
- **Wavelength of light**
  - The refractive index varies with wavelength linearly because different wavelengths interfere to different extents with the atoms of the medium.
  - It is important to use monochromatic light to prevent dispersion of light into different colours.
  - The chosen wavelength should not be absorbed by the medium.
  - The sodium D line at 598 nm is the most frequently used wavelength of light for a refractometer.

- Because the RI of a substance is strongly influenced by temperature and the wavelength of light used to measure it, therefore, care must be taken to control or compensate for temperature differences and wavelength.
- RI measurements are usually reported at a reference temperature of 20 degrees Celsius, which is equal to 68 degrees Fahrenheit, and considered to be room temperature.
- A reference wavelength of 589.3 nm (the sodium D line) is most often used.
- Though RI is a dimensionless quantity, it is typically reported as nD20 (or n^{20}_{D}), where the "n" represents refractive index, the "D" denotes the wavelength, and the 20 denotes the reference temperature.
- Therefore, the refractive index of water at 20 degrees Celsius, taken at the Sodium D Line, would be reported as 1.3330 nD20.

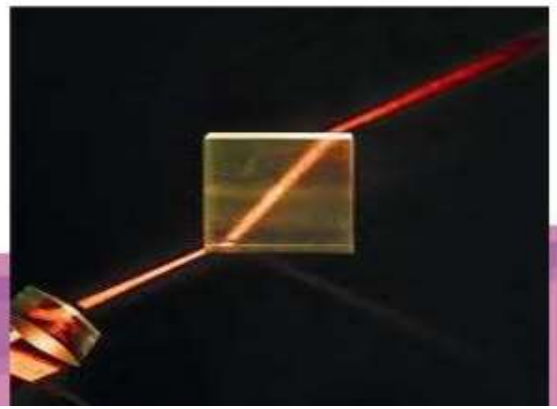
REFRACTIVE INDEX (conti...)

It is also commonly used to:

- Help identify or confirm the identity of a sample by comparing its refractive index to known values.
- Assess the purity of a sample by comparing its refractive index to the value for the pure substance.
- Determine the concentration of a solute in a solution by comparing the solution's refractive index to a standard curve.

REFRACTOMETER

- A refractometer measures the extent to which light is bent (i.e. refracted) when it moves from air into a sample and is typically used to determine the refractive index (n) of a liquid sample.
- The refractive index is a unitless number, between 1.3000 and 1.7000 for most compounds
- The refractive index is a quantity which is a constant for a pure substance under standard conditions of temperature and pressure.



INSTRUMENTATION

TYPES OF REFRACTOMETER

ABBE'sREFRACTOMETER

IMMERSION OR DIPPING REFRACTOMETER

PULFRICH REFRACTOMETER

I.) ABBE REFRACTOMETER

- Light refraction through liquids to determine the amount of dissolved solids in liquids by passing light through a sample and showing the refracted angle on a scale.
- RI of the prism should be greater than that of the sample
- In abbe refractometer, the RI can be read directly, only a few drop of the liquid are needed , and either white or monochromatic light can be used.
- This refractometer consist, mainly a telescope and two matched right angle prisms.

I.) ABBE REFRACTOMETER (conti...)

- The liquid is placed in contact with the prisms.
- Many refractometers are equipped with a thermometer and a means of circulating water through the refractometer to maintain a given temperature.
- Most of the refractive index measurements reported in the literature are determined at 20 or 25 °C.
- Operation consists of placing 1 or 2 drops of the water sample on the prism, closing a glass plate over the sample, then looking through the eyepiece for the reading

Abbe refractometer:

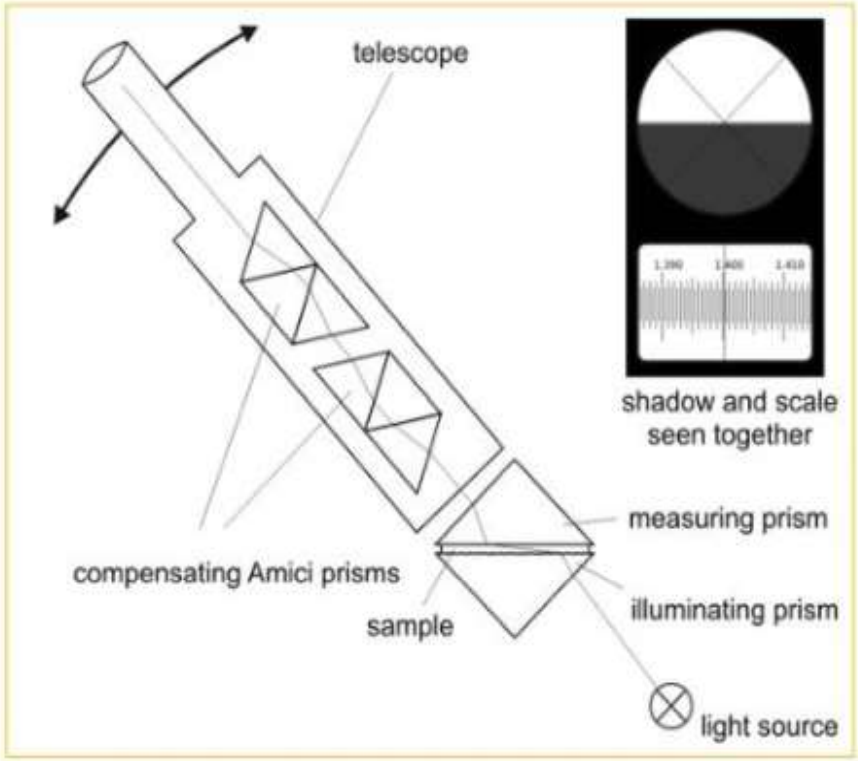
- *Abbé refractometer working principle is based on* ***critical angle.***
- *Sample is put between two prisms - measuring and illuminating.*
- *Light enters sample from the illuminating prism, gets refracted at critical angle at the bottom surface of measuring prism,*
- *then the telescope is used to measure position of the border between bright and light areas.*

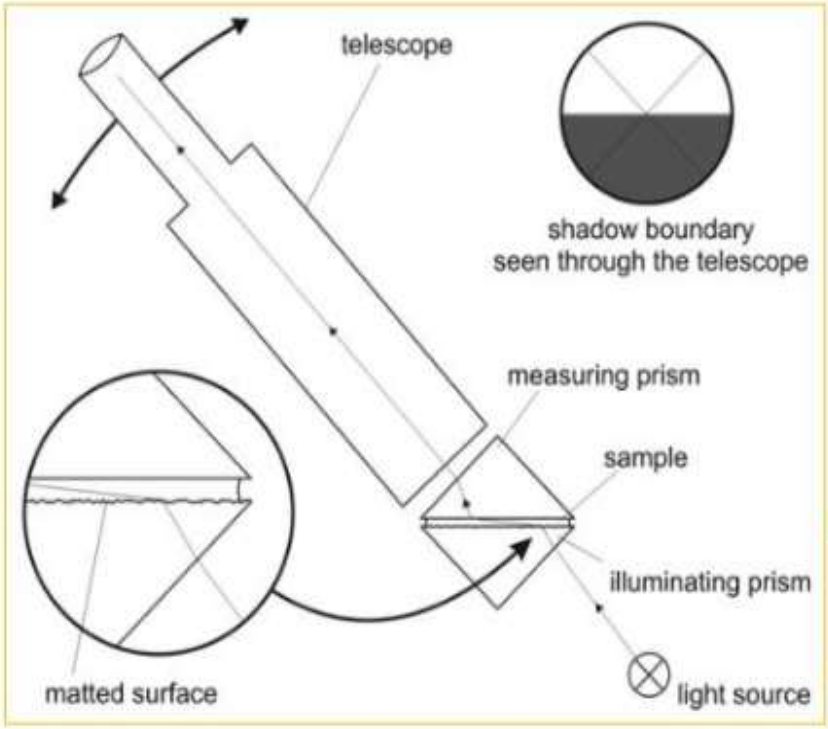
- *Telescope reverts the image, so the dark area is at the bottom, even if we expect it to be in the upper part of the field of view.*

- *Surface of the illuminating prism is matted, so that the light enters the sample at all possible angles, including those almost parallel to the surface.*

- *To prevent dispersion , Abbé added two compensating Amici prisms into his design.*

- *Not only telescope position can be changed to measure the angle, also position of Amici prisms can be adjusted, to correct the dispersion.*

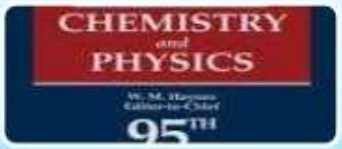

telescope
shadow and scale
seen together
measuring prism
compensating Amici prisms
illuminating prism
sample
light source


telescope
shadow boundary
seen through the telescope
measuring prism
sample
illuminating prism
matted surface
light source

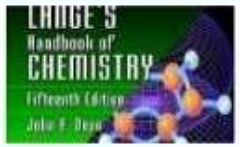
Analyzing Results Finding Refractive Indexes:

➢Comparison with the literature to know the identity of the compound or to asses its purity

The following sources list refractive indexes for a wide variety of substances:



The CRC Handbook of Chemistry and Physics



Lange's Handbook of Chemistry

The Merck Index

Chemical catalogs (e.g., the one from Aldrich Chemical Co.) MSDS datasheets

Specific Refraction

a parameter characterizing the electronic polarizability of a unit mass of a substance in the high-frequency electromagnetic field of a light wave. The specific refraction *r* of a substance is eq ual to the substance's molecular refraction *R* divided by its molecular weight *M*. Specific refraction may be expressed in ter ms of a substance's index of refraction *n* in several ways; the form most often used is

where ρ is the density of the substance.

$$r = \frac{1}{\rho}\frac{n^2 - 1}{n^2 + 2}$$

MOLAR REFRACTIVITY

Molar refractivity, A, is a measure of the total polarizability of a mole of a substance and is dependent on the temperature, the index of refraction, and the pressure.
The molar refractivity is defined as

$$A = \frac{4\pi}{3} N_A \alpha,$$

Where, $N_A \approx 6.022 \times 10^{23}$

is the Avogadro constant and α is the mean polarizability of a molecule.

Substituting the molar refractivity into the Lorentz-Lorenz formula gives, for gases

$$A = \frac{RT}{p} \frac{n^2 - 1}{n^2 + 2}$$

where n is the refractive index, p is the pressure of the gas, R is the universal gas constant, and T is the (absolute) temperature.

APPLICATIONS & USES

1) It is used in the examination of organic compounds (oils, solvents, etc.), solutions, food products, serum protein concentration.

2) In veterinary medicine, a refractometer is used to measure the total plasma protein in a blood sample and urine specific gravity.

3) In gemmology, a refractometer is used to help identify gem materials by measuring their refractive index.

4) Since the index of refraction of a pure substance is constant at constant temperature and pressure, it can be used as a means of identification.

5) It is used to determine the purity of oils, fats, and waxes.

6) It is used to determine the amount of sugar in sugar solutions and in general, for determining total solids in fruit juices, tomato products, honey, syrups and soda water

THANK YOU