American International Journal of Research in Science, Technology, Engineering & Mathematics

Available online at http://www.iasir.net

ISSN (Print): 2328-3491, ISSN (Online): 2328-3580, ISSN (CD-ROM): 2328-3629

AIJRSTEM is a refereed, indexed, peer-reviewed, multidisciplinary and open access journal published by International Association of Scientific Innovation and Research (IASIR), USA

(An Association Unifying the Sciences, Engineering, and Applied Research)

Refractive Index of Acetone-Water mixture at different concentrations

Mukesh Upadhyay*, Sara Um Lego
*Department of Physics
North Eastern Regional Institute of Science & Technology
Nirjuli, Itanagar, Arunachal Pradesh – 791109 [India]

Abstract: *The refractive index of a substance is an optical property of matter that has been measured and interpreted since the early nineteenth century .The study of data for liquids and their binary mixtures, is important for developing a better understanding of the liquid state .The measurement of refractive index help us to understand about different properties of substances like optical and electrical properties and is also used as a tool for classification.*

Key words: *Refractive index, Refractometer, Optical prism*

I. Introduction

The refractive index of a substance depends on various parameters, such as frequency, wavelength, pressure, temperature. When light passes through different substances its velocity changes, increasing the refractive index of these substances. It can be due to interaction between molecules of components in substrate and effect of these interactions on light. Also in most substrates, the refractive index decreases by increasing of the temperature. As interaction between molecules decreases as the temperature is increase. Light of different colors have different bending angles, as the speed changes with wavelength. One observed a change in the refractive index corresponding to a specific color in the spectra.

Typically, at ambient temperature and pressure the refractive index of common molecular and ionic liquids lies in the range 1.2– 1.6 and can be easily and accurately determined experimentally with uncertainties as low as 0.5×10^{-4} or even 2×10^{-6} in the case of differential measurements[1,2].Refractive index has the large number of applications. It is mostly applied for identify a particular substance, confirm its purity, or measure its concentration. Generally it is used to measure the concentration of a solute in an aqueous solution. It can be used also in determination of drug concentration in pharmaceutical industry.

II. Theory

The refractive index of a material can be measure by various methods. It is generally determined using interferometric techniques or deflection methods.In the latter, refractive index is measured by refractometers based on the critical angle effect. A refractometer is a laboratory or a field device for the measurement of the index of refraction. There are four main types of refractometers: traditional handheld refractometers, digital handheld refractometers, laboratory or Abbe refractometer and inline process refractometers[3].

The work in this paper, carried out for the determination of refractive index of the given liquid samples is done by the Abbe refractometer. It was first developed by Ernst Abbe in 1869 at Jena, Germany.The Abbe instrument is the most convenient and widely used refractometer. It is a double prism system shown in **Fig 1**, consisting of the two optical prisms (illuminating and refracting) with the thin layer of the liquid sample between them. The upper prism is firmly mounted on a bearing that allows its rotation by means of the side arms. The lower prism is hinged to the upper to permit separation for cleaning and for introduction of the sample. The face of lower prism is rough ground; when light is reflected into the prism, this surface effectively serve as the source for an infinite number of rays that passes 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. The eyepiece of the telescope is provided with crosshairs and in making the measurement, the prism angle is changed until the light-dark interface just coincides with the crosshairs. The position of the prism is then established from the fixed scale, simple readout from the scale of refractometer then provides the refractive index directly, or it can be readily determined using a conversion table. In both configurations, the light is incident to a prism as it travels inside the sample. The measuring prism is made of a glass with a high refractive index (μ>**1.75**), which allows this refractometer to measure refractive indices up to μ<**1.75.**

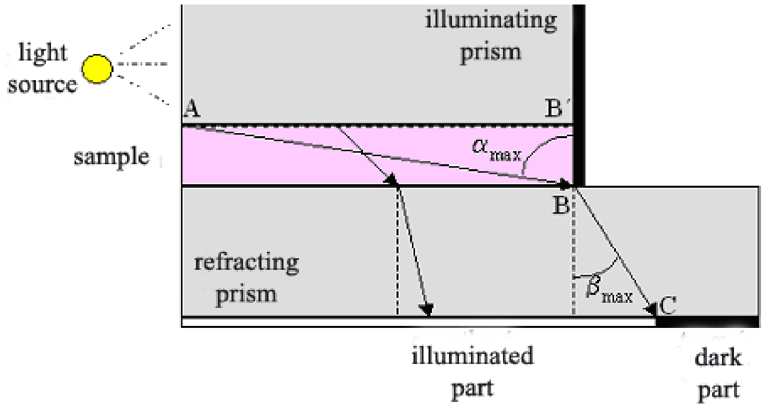


Fig 1- Schematic diagram of Abbe Refractometer

These refractometers are more suitable for transparent samples. An alternative to analyze turbid or absorbing media is based on internal reflection devices [4–6], where the imaginary part of the refractive index also can be obtained.

The Abbe refractometer is very popular and owes its popularity to its convenience, its wide range (μ = 1.3 to 1.7) and to the minimal samples needed. The accuracy of the instrument is about ± 0.0002; its precision is half this figure.The determination of refractive index is performed using a single wavelength. One important aspect is the dependency of the refractive index on the wavelength of the light beam. This is also called dispersion. It is different for all substances. Refractive indices are therefore stated for monochromatic light of wavelength 589 nm, corresponding to the sodium D line.

If the Abbe refractometer is used with daylight, a colored fringe can be recognized at the light-dark interface which prevents accurate measurements. However, the Abbe refractometer possesses a correction mechanism which minimizes the colored fringe. To correct the dispersion, two Amici roof prisms in line can be rotated against one another using an adjustment screw in such a way that the refraction of the red and blue-green wavelengths can be progressively corrected while the yellow light remains unaffected. By turning the adjustment screw for dispersion correction, the colored fringe can be made to disappear. The refractive index thus obtained is with reference to the sodium D line.

III. Method

The monochromatic light source used is a Sodium vapor lamp which is gas-discharge lamp that uses sodium in an excited state to produce light at a characteristic wavelength near 589 nm.

A thin layer of the pure liquid samples whose refractive index are to be measure is applied on the lower refracting prism. The adjustment knob is scanned until a light and dark divided image can be seen. Center the boundary in the crosshairs of the telescope and with the help of the side scale the refractive index is determined. This data is tabulated and using equation K = μ^2, the dielectric constant of the different liquid samples is calculated.

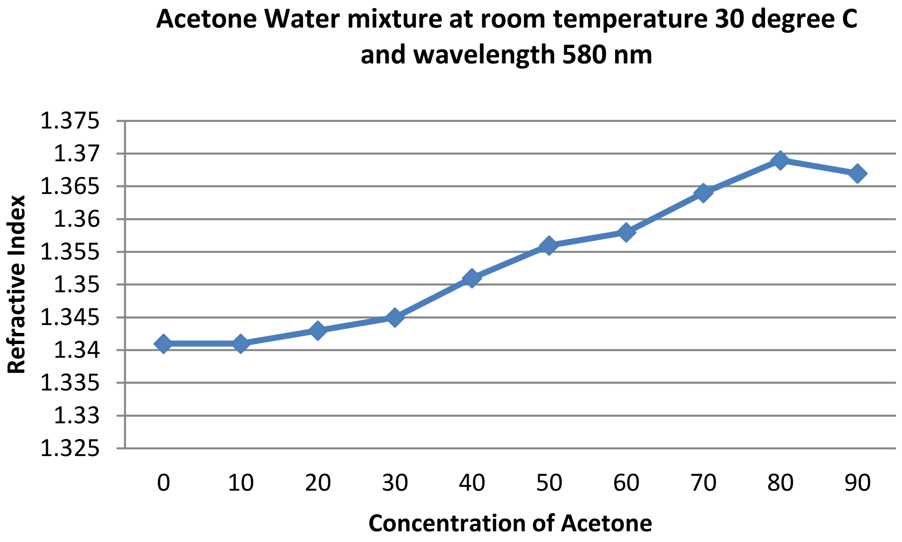
The acetone-water mixture samples are prepared by mixing several concentration of acetone ranging from 10% to 90% in distilled water. A 10ml solution of acetone-water mixture is prepared by dissolving 1ml acetone in 9ml of water. A thin layer of the sample prepared is place in between the prisms of the Abbe refractometer and the refractive index is calculated. Likewise several samples are prepare with 2ml, 3ml, 4ml, 5ml, 6ml, 7ml, 8ml and 9ml of acetone in 10ml solution with water and the refractive indices of the samples are measured and recorded.

IV. Result and conclusion

Refractive indices of acetone and water mixtures were measured at a particular temperature 30℃ and at wavelength 589 nm with the concentration of acetone ranging from 0 to 90% by volume.The result is tabulated as follows:

Sl. No.	Concentration of Acetone (%)	Refractive Index
1	0	1.340
2	10	1.341
3	20	1.343
4	30	1.345
5	40	1.350
6	50	1.356
7	60	1.358
8	70	1.364
9	80	1.369
10	90	1.367

A graph is plotted between concentration and the refractive index determined.



From the graph it is evident that the refractive index of the acetone and water mixture varies linearly with the increased in concentration of acetone in the solution upto a certain concentration and further increase in concentration result in the decrease of refractive index.

In binary mixture of acetone and water, depending on the number of molecules present and the magnitude of their radii, the different molecules can be closely or less closely packed. When acetone molecule are dissolved in water, due to the formation of hydrogen bond between the different molecules, cause increase in the volume contraction of the sample as the change resulting from the close packing of water and acetone is greater in magnitude than normal forces of repulsion. When the close packing is maximum, the intermolecular spaces are reducing to minimum; hence contraction in volume is maximum. As the concentration of acetone in the solution is increase from 0% to 80%, the close packing of molecule increases until it reaches maximum value. The interspaces being diminished cause the increase in refractive index. With further increase in concentration of acetone, the close packing becomes probably smaller, hence the decrease in the refractive index for higher concentration. The main factors present in the mixture are diminution of intermolecular spaces of water, interaction between acetone and water influenced by structural and polar characteristics of both acetone and water molecules, and association of acetone. The first factor cause increase in refractive index resulting from the decrease in the free spaces in water molecule, until a maximum value corresponding to the disappearance of the open structure of water is reached. A further influence upon refraction is due to the attraction between water and acetone molecules and to the association of acetone. A picture of associated molecules determined indicates a rather open structure of molecular clusters formed by means of Hydrogen Bridge of the hydroxyl group. Such a picture is in agreement with decreasing values in refractive index.

It is clear from the tabulated results that the refractive index for acetone and water mixture is maximum for 80% concentration of acetone. Above this concentration of acetone the value of refractive index starts to decrease.

The refractive power of a molecule is thus an additive and constitutive property depending on the number and kinds of atoms present and on the way these atoms are linked together.

References

[1]. Nowakowska, Janina, "The Refractive Indices of Ethyl Alcohol and Water Mixtures", 668,1939.
[2]. J. R. Partington, An Advanced Treatise on Physical Chemistry, Physico-Chemical Optics, Longmans, London, 4, 1953.
[3]. J. O. Hirschfelder, C. F. Curtiss, R. B. Bird, Molecular Theory of Gases and Liquids, Wiley, New York, 1954.doi 10.1002/pol.1955.120178311
[4]. Prigogine, I., Bellemans, A, Mathot, V., “Molecular Theory of Solutions,” Interscience. New York, 180, 1957.
[5]. Rowlinson, J.S., “Liquids and Liquid Mixture,” Academic Press, Kew York, 111, 1959.
[6]. S. Singh, “Refractive index measurement and its applications,” Phys. Scr. 65, 167,2002.