Study of Effect of Concentration on Refractive Index of Some Salt Solutions

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Abstract

A simple and reliable method of measuring the refractive index of solution is reported in the present paper. Abbe Refractometer is employed to study the concentration dependence of refractive index of some salt solutions (KCl, KBr and KI). This technique can be safely used in the study of the optical properties of any transparent liquids.
Keywords: Salt solution, Concentration, Abbe Refractometer, Light.

Introduction

Refractive index is one of the most important optical properties of a medium. It is a fundamental property of a solution which can vary with temperature, composition, concentration and incident light wavelength. It plays vital role in many areas of material science especially in thin film technology and fibre optics and in many branches of science like physics, biology and chemistry and engineering. Knowledge of the refractive index of aqueous solutions of salts and biological agents is of crucial importance in applications of evanescent wave techniques in biochemistry. It is mostly applied to identify a particular substance, confirm its purity and measure its concentration. Mostly it is used to determine the concentration of a solute in an aqueous solution. In case of sugar solution, the refractive index can be used to determine the sugar content (Brix degree). It can also be used in determination of drug concentration in pharmaceutical industry. It is used to determine the focusing power of lenses and the dispersive power of prisms. It is used for estimation of thermo physical properties of hydrocarbons and petroleum mixtures. Poonam Pendke and K. Das have used Abbe refractometer for measuring refractive indices of the polymer. They studied the variation of refractive indices with wavelength for pure and doped PMMA samples at various temperatures. For all the temperatures the refractive indices was found to be decreasing with increasing wavelengths and by increasing doping % its refractive indices was also found to be increases [1]. Subedi D.P., Adhikari D.R., Joshi U.M., Poudel H. N. and Niraula B. have used specially constructed hollow prism to measure the refractive index of liquids with the help of an optical spectrometer. They studied the variation of refractive index of water as a function of temperature and showed a linear dependence of refractive index of water on temperature in the range 30°C- 70°C. They also studied the variation of refractive index of common salt, sugar, propanol-1, sucrose and potassium chloride solution with concentration and found the linear dependence of refractive index on concentration [2]. U.V. Biradar and S.M. Dongarge have studied the variation of refractive index of NaCl salt solution with concentration and found the linear dependence of refractive index on concentration [3]. Zhu Xingyu, Mai Tiancheng and Zhao Zilong have presented the variation of refractive index of multi component system ($CuSO_4$-NaCl-H_2O) related to each solute's molar concentration and found a linear relationship [4]. Manu Joseph and Ignatius J. have shown that the refractive index has a linear dependence on the concentration in addition to temperature in the case of Zinc acetate and Lead acetate solution [5]. Jassim

Mohamed Jassim and Noor Salah Khudhair have explained the effect of temperature and concentration on the refractive index of water using the Michelson interferometer [6]. Chang-Bong Kim1 and Chin B Su measured the refractive index of water and several liquids at wavelengths of 1310 and 1551 nm using the fibre optic Fresnel ratio meter [7]. A. Joshi, N. D. Haynes, D. E. Zelmon, O. Stafsudd and R. Shori have conducted measurements of the refractive index as a function of wavelength and its dependence on temperature and concentration of Er^{3+}doped ceramic Y_2O_3 [8]. Ruy Batista Santiago Neto, Jos´e Paulo Rodrigues Furtado de Mendonc¸a and Bernhard Lesche have determined the absolute values of refractive index of of transparent liquids using an Interferometric Method [9]. U.V. Biradar, S.M. Dongarge and N. V. Wani have studied the variation of refractive index of KCl salt solution with concentration and found the linear dependence of refractive index on concentration [10]

Material and Method

Abbe Refractometer Model RSR-1 is available in our laboratory which is widely used in industries in diversified fields, for research and development and in teaching establishment. It provides a fast and convenient method of measuring refractive index and mean dispersion of transparent liquids, solutions and solids. The instrument is capable of determining the percentage of sugar contents in saccharose solutions. It delivers consistent repeatable results free from user subjectivity. Accuracy of the refractive index is 0.001 by direct reading and 0.0001 by estimation.

A ray of monochromatic light passing from one medium into another is refracted or bent towards or away from the normal depending upon the optical nature of two media. According to Snell's law- R.I. (n) = sin i / sin r. Refractive index depends upon temperature, the chemical nature of substance and wavelength of the light. If the second medium is solution, refractive index also depends upon the concentration of the solution. So it can be used to identify a pure substance and to determine the composition of homogeneous transparent binary mixture.

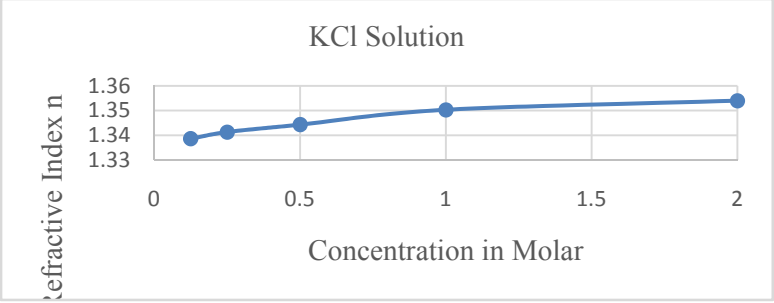
Experimental procedure for measuring refractive index is followed as per given in the manual provided with the instrument. To study the variation of refractive index of KCl, KBr and KI solution as a function of concentration, an electronic balance is used to the weigh the salts and solutions of 2M concentrations are prepared by dissolving the salts in 50 ml of distilled water. Solutions of lower concentrations (1M, 0.5M, 0.25M and 0.125M) are prepared by diluting with water.

Result and Discussion

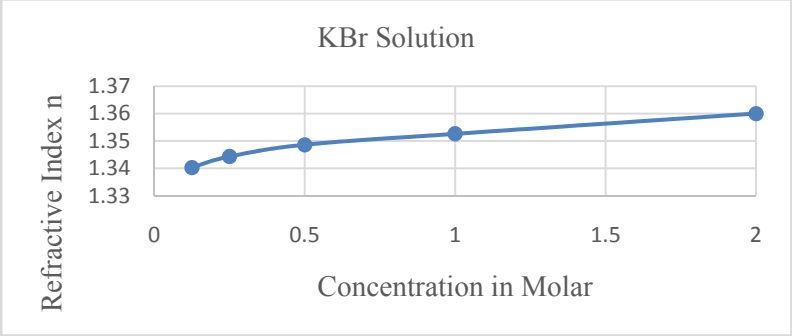
Refractive index of salt solutions KCl, KBr and KI as a function of concentration is depicted in Table 1, 2 and 3 respectively. In case of all three salt solutions, it is found that the refractive index is decreased when the concentration is reduced. For 2M solution, refractive index is as high as 1.3540 (KCl), 1.3600 (KBr) and 1.3623 (KI) which reduces to 1.3386 (KCl), 1.3403 (KBr) and 1.3453 (KI) when the solution is diluted to a concentration of 0.125M.

Conc.	Table 1: *Refractive Index of KCl Solution*			
	I	**II**	**III**	**Mean**
2.0 M	1.355	1.353	1.354	1.3540
1.0 M	1.350	1.351	1.350	1.3503

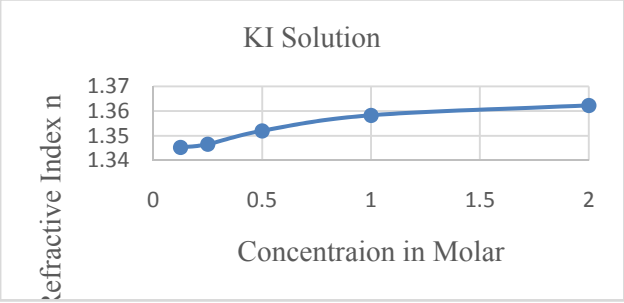
0.5 M	1.345	1.344	1.344	1.3443
0.25M	1.341	1.341	1.342	1.3413
0.125 M	1.338	1.339	1.339	1.3386



Conc.	Table 2: *Refractive Index of KBr Solution*			
	I	**II**	**III**	**Mean**
2.0 M	1.359	1.360	1.361	1.3600
1.0 M	1.353	1.353	1.352	1.3526
0.5 M	1.348	1.349	1.349	1.3486
0.25M	1.344	1.344	1.345	1.3443
0.125 M	1.340	1.341	1.340	1.3403



Conc.	Table 3: *Refractive Index of KI Solution*			
	I	**II**	**III**	**Mean**
2.0 M	1.363	1.362	1.362	1.3623
1.0 M	1.358	1.359	1.358	1.3583
0.5 M	1.351	1.353	1.352	1.3520
0.25M	1.346	1.347	1.347	1.3466
0.125 M	1.345	1.345	1.346	1.3453



It is because with the decrease in concentration, the density of the solution also decreases resulting a decrease in refractive index. This linear dependence of refractive index with concentration is also presented in the form of graph.

Refractive Index of Water = 1.3310

Conclusion:

Experimental results showed that Abbe Refractometer technique could be safely employed to study the dependence of refractive index of solutions on their concentration. A linear dependence of refractive index of salt solutions on their concentration was observed.

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