IRJSE International Research Journal of Science & Engineering
Int. Res. J. of Science & Engineering, 2020; Special Issue A7: 48-51 SJIF Impact Factor 6.68
ISSN: 2322-0015
RESEARCH ARTICLE **OPEN ACCESS**

Study of Hydration number in binary liquid mixtures.

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Manuscript Details
Available online on http://www.irjse.in
ISSN: 2322-0015

Cite this article as:
Ganjare Pravin J, Aswale Sunanda S, Aswale Shashikant R. Study of Hydration number in binary liquid mixtures, *Int. Res. Journal of Science & Engineering,* February 2020, Special Issue A7: 48-51.

ABSTRACT

The ultrasonic velocity and density are measured for liquid mixtures of sodium-2-hydroxy benzoate in water as a solvent at 298.15K, 303.15K, 308.15K temperature and 0.1M, 0.01M, 0.001M concentration. From the measured values of ultrasonic velocity and density of solution and solvent, values of apparent molar volume and molar hydration number are calculated. Any solute when dissolved in solvent. Dissolution of solute molecules takes place by solvation process. The number of solvent molecules participates in the process of solvation is related with the solvation number or molar hydration number. The strength of the interactions in the solution analyzed with change in concentration and temperature by the evaluation of calculated parameters like apparent molar volume and molar hydration number.

Keywords: Ultrasonic velocity, density, apparent molar volume and molar hydration number.

INTRODUCTION

The measurement of ultrasonic velocity and other thermodynamic parameters provides wealth of information about the state of liquid mixtures. Many researchers carried out extensive investigations in this regards about the aqueous solutions[1-6] . In the process of solvation of solute by solvent, interactions takes place between solute ions and solvent molecules.

The number of water molecules that interacts with solutes are the measure of molar hydration number. Many researchers showed that the solute-solvent sheath which is formed due to solute-solvent interaction are incompressible in comparison with the free solvent molecules[7]. Many methods are developed to calculate hydration number[1 and8]. A new method arrived to calculate molar hydration number by measurement of ultrasonic velocity which is reported by Kalyansundaram S., Bhawanth R. and others[9-10]. The apparent molar volume is the parameter which gives us an idea about the volume occupied by solute molecules in the solution[11] **.**

In the present investigation, molar hydration number (h) and apparent molar volume (ϕ_v) of aqueous solutions of sodium-2-hydroxy benzoate are calculated from the measured values. Molar hydration number and apparent molar volume have been studied at various concentrations and temperature ranging from 0.1M, 0.01M ,0.001M and 298.15K, 303.15K and 308.15K respectively. The results analyzed are presented in terms of solute-solvent interactions.

METHODOLOGY

Materials : Sodium-2-hydroxy benzoate used was of A.R. grade. Distilled water was used as a solvent for the preparation of solutions. Weights have been taken on digital electronic balance. (Model-CB/CA/AT-Series).

Methods : The ultrasonic velocity was measured by using ultrasonic interferometer (Model-M-83). Mittal Enterprises, New Delhi) operating at 4MHz frequency with an accuracy of ±2m/s. The densities (ρ) were measured accurately using digital densitometer (Model - DMA-35, Anton Paar). The ultrasonic speed was measured at 4MHz frequency at 298.15K, 303.15K and 308.15K. The temperature of cell was maintained with continuous circulation of water at constant temperature by using thermostat.

RESULTS AND DISCUSSION

The values of molar hydration number and apparent molar volume are calculated from the measured values of ultrasonic velocity(v), density (ρ) by using standard formulae and are given in **Table No. 1**

$$\phi_v = [1000(d_o - d_s)/C.d_o] + (M/d_o) \quad \text{---------- 1}$$

Where
do – Density of solvent
Do – Density of solution, C- Molar concentration

$$h = n_w/n_s[1-(\beta_s/\beta_o)] \quad \text{----------2}$$

n_w – Number of moles of water, n_s – Number of moles of solute.
β_s – Adiabatic compressibility of solution.
β_o - Adiabatic compressibility of solvent.

Table .1 : Molar hydration number and apparent molar volume (ϕ_v) of sodium-2- hydroxy benzoate in water.

Sr.No.	Temperature (^{0}K)	Concentration (M)	Apparent molar volume (ϕ_v) (m^3/mole)	Molar hydration number (h)
01	298.15	0.1	1.16E+00	4.83E+03
02		0.01	1.55E+03	4.82E+04
03		0.001	2.87E+04	4.81E+05
04	303.15	0.1	7.54E+01	4.61E+03
05		0.01	1.54E+03	4.93E+04
06		0.001	2.90E+04	5.15E+05
07	308.15	0.1	7.55E+01	4.53E+03
08		0.01	1.57E+03	4.83E+04
09		0.001	2.93E+04	4.91E+05

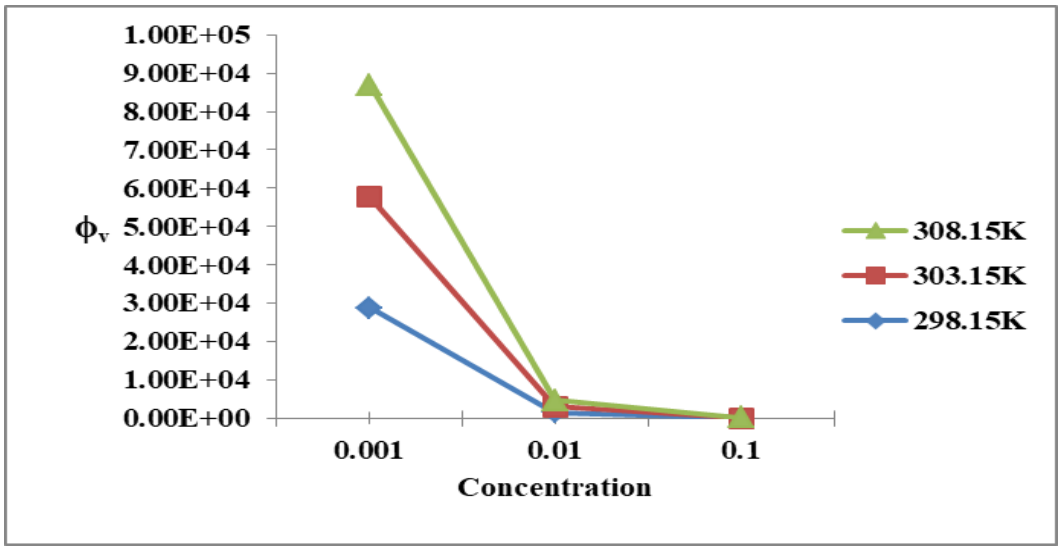

Fig.-1: Apparent molar volume (ϕ_v)Vs Concentration (Sodium-2-hydroxy benzoate)

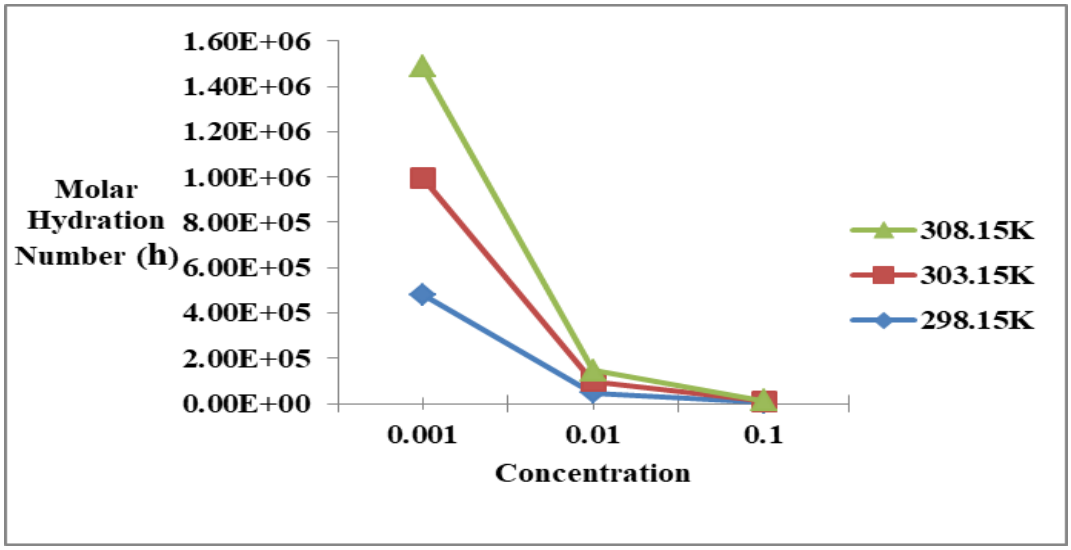

Fig.-2: Molar hydration number (h) Vs Concentration (Sodium-2-hydroxy benzoate)

The results of the studies summarized are presented in the **Table-1, Fig. 1 and Fig. 2.** The present investigation deals with the determination of molar hydration number and apparent molar volume. Calculated values of apparent molar volume are plotted against the concentration for different temperatures shown in **fig. 1.** Apparent molar volumes are particularly relevant to determine the molecular interactions (solute - solute, solute - solvent, and solvent - solvent) happening in solutions[12]**.** Also, at infinite dilution, the apparent molar volumes of solutions are useful to obtain information regarding solute to solvent and solvent to solvent interactions. In the present investigation, apparent molar volume decreases with increase in concentration. Observed values of apparent molar volume (ϕ_v) show that values increases with increase in temperature for all concentrations. **fig. 1** show the variation in (ϕ_v) values with concentration. This highlights that the overall order of the structure is improved or increased in solution with rising temperature[13]. Water molecules are polar in nature. Water molecules attach to ionic solute by strong electrostatic forces which introduces the great cohesion in the solution[14]. The hydration number is determined by using adiabatic compressibility which is calculated by the measurement of ultrasonic velocity and density. water molecules are bound to an solute ions more firmly than water molecules. Cluster formation may takes place between sodium -2-hydroxy benzoate and water

molecules due to salvation. From **fig. 2**, Decrease in the values of hydration number with increase in concentration shows that the number of solute molecules increases in the given volume. This indicates lesser surface area is present for water molecules for solvation because of bigger size of solute molecule comparing to water molecules. Decrease in the molar hydration number with increase in concentration can be explained on the basis of variation of density of solutions. The value of density increases with increase in concentration. These values are very much correlated with the values of apparent molar volume. The increase in density and decrease in molar hydration number shows that solvation is higher at 0.001M concentration and minimum at 0.1M concentration which means ions carries less number of water molecules with it. With variation in temperature, some irregular variations are observed.

CONCLUSION

Text must be type in Book Antiqua font size 10. Text Solvation decreases at high concentration for the present system. This also indicates that increase in the number of solute molecules forms compact structure between solute-solute and somewhat in between solute-solvent. It can be conclude that solvation of sodium ion also interferes in the solvation of salicylate ions and presence of two functional groups **–OH** and **–COO$^-$** on solute ion forms cluster with water molecules.

Conflicts of interest: The authors stated that no conflicts of interest.

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