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# Acoustical Properties of Binary Mixture at 298k and at 2 MHz Frequency

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## ABSTRACT

Measurements of ultrasonic velocity, density and viscosity have been carried out in Acetonitrile in 1,4 Dioxane at different concentrations at 298 K temperature and 2 MHz frequency. Ultrasonic studies may throw more light on the molecular interaction to know the behavior of solute and solvent molecules in liquid mixtures and solutions. Acoustical parameters as adiabatic compressibility ($\beta_a$), intermolecular free length ($L_f$) and free length ($\tau$)for Acetonitrile in 1,4 Dioxane were calculated from ultrasonic velocity and effect of concentration on molecular interaction was predicted.

**Keywords:** Acetonitrile, Concentration, 1,4 Dioxane, Molecular, Ultrasonic

## I. INTRODUCTION

study of ultrasonic waves in pure liquids and liquid mixtures is useful to predict the nature of intermolecular interactions exist in these liquids and liquid mixtures. Liquid mixtures consisting of polar and non-polar components are of immense importance. When two or more liquids are mixed, there occur some changes in physical and thermodynamic properties because of free volume change, change in energy and change in molecular orientations. Thermodynamic and acoustical parameters like adiabatic compressibility ($\beta a$), intermolecular free length ($L_f$) and relaxation time ($\tau$) are of considerable interest in understanding the inter-molecular interactions in binary liquid mixtures. Ultrasonic studies have been found to be useful in describing the theory of liquid state of matter. The density ($\rho$), ultrasonic velocity (U) and viscosity ($\eta$) can be used to study the physicochemical behavior and molecular interactions in pure liquids, liquid mixtures and solutions [1-6].

The various acoustic parameters such as ultrasonic velocity, density, viscosity, adiabatic compressibility, free length and free volume are useful in understanding molecular structure and molecular interactions in the medium. Thermodynamics studies of binary liquid mixtures have attracted much attention of scientists. These physico-chemical analyses are used to handle the mixtures of hydrocarbons, alcohols, aldehydes, ketones etc. The measurement of ultrasonic speed enables us to the accurate measurement of some useful acoustic and thermodynamic parameters and their excess values [7-9]. These excess values of ultrasonic velocity, adiabatic compressibility, molar volume and viscosity in binary liquid mixture are useful in predicting the solute-solvent interactions. The variation in ultrasonic velocity gives information about the bonding between molecules and formation of complexes at various concentration and temperature through molecular interactions. Acetonitrile is used to make perfumes,pharmaceuticals, rubber products, pesticides, acrylic nail removers and batteries. It is also used to extract fatty acids from animal and vegetable oils. [10-11].

## II. METHODS AND MATERIAL

The ultrasonic velocity (U) in liquid mixtures have been measured using an ultrasonic interferometer (Mittal type, Model F-81) working at 2 MHz frequency and at temperature 298K. The accuracy of sound velocity was ±0.1 $ms^{-1}$. An electronically digital operated constant temperature water bath has been used to circulate water through the double walled measuring cell made up of steel containing the experimental solution at the desire temperature. The density of pure liquids and liquid mixtures was determined using pycknometer by relative measurement method with an accuracy of ±0.1$Kgm^{-3}$. All the precautions were taken to minimize the possible experimental error.

Adiabatic compressibility (βa), Intermolecular free length ($L_f$) and free length (τ)have been calculated from the measured data using the following standard expressions:

$$\beta_a = (U^2\rho)^{-1} \quad .... \quad (1)$$

$$L_f = K_T\beta a^{1/2} \quad .... \quad (2)$$

$$\tau = 4/3\, \eta\, \beta a \quad ... \quad (3)$$

Where, $K_T$ is the temperature dependent constant, η be the viscosity.

## III. RESULTS AND DISCUSSION

Table-I shows that, Ultrasonic velocity and density decreases with concentration in Acetonitrileat temperature 298K. The viscosity decreases in the system, suggesting thereby less association between solute and solvent molecules. Decrease of velocity with increase in molefraction suggest weak solute solvent interaction existing in the solution.

From the Table-I, the adiabatic compressibility and free length increases with increase of mole fraction of the Acetonitrile. This may lead to the presence of weak molecular interaction between the molecules of the liquid mixture. The adiabatic compressibility and free length are the deciding factors of the ultrasonic velocity in liquid systems. Increase in intermolecular free length in the system leads to deviation in compressibility.

The free length increases with increasing mole fraction of the solute in this system. The increase in free length show that the strength of interaction decreases gradually with the increase in Acetonitrile concentration. It represents that there is weak molecular interaction between the Acetonitrile and 1,4 Dioxane. [12-14].

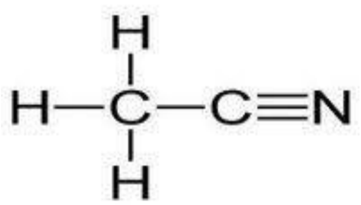


**Table 1:** Measured values of Ultrasonicvelocity (U), density (ρ) and viscosity (η) and calculated values of Adiabatic compressibility ($\beta_a$), free length ($L_f$) and free length (τ) of Acetonitrile + 1,4 Dioxaneat 298K and 2 MHz Frequency.

| Mole fraction | U (m/s) | ρ (kg/m³) | $\eta*10^{-3}$ (CP) | $\beta_a*10^{-10}$ ($Pa^{-1}$) | $L_f*10^{-10}$ (m) | $\tau*10^{-12}$ (s) |
|---|---|---|---|---|---|---|
| 0 | 1350.00 | 1030.00 | 0.5 | 5.33 | 0.475 | 0.3551 |
| 0.1 | 1338.10 | 1003.14 | 0.484 | 5.57 | 0.486 | 0.3592 |
| 0.2 | 1328.66 | 982.10 | 0.471 | 5.77 | 0.494 | 0.3622 |
| 0.3 | 1319.33 | 956.00 | 0.457 | 6.01 | 0.505 | 0.3661 |
| 0.4 | 1313.00 | 825.16 | 0.445 | 7.03 | 0.546 | 0.4170 |
| 0.5 | 1307.67 | 891.10 | 0.431 | 6.56 | 0.527 | 0.3771 |
| 0.6 | 1302.00 | 866.23 | 0.421 | 6.81 | 0.537 | 0.3822 |
| 0.7 | 1299.00 | 843.00 | 0.407 | 7.03 | 0.546 | 0.3814 |
| 0.8 | 1295.10 | 828.36 | 0.395 | 7.20 | 0.552 | 0.3855 |
| 0.9 | 1289.66 | 815.96 | 0.382 | 7.37 | 0.559 | 0.3895 |
| 1.0 | 1284.00 | 803.00 | 0.371 | 7.55 | 0.565 | 0.3947 |

## IV. CONCLUSION

The ultrasonic velocity, density, viscosity and other related parameters were calculated. The existence of molecular interaction in solute-solvent is favored in the system, confirmed from the U, ρ, η, βa, $L_f$ and τ data. The variation in ultrasonic velocity (U), density (ρ) and viscosity (η) and other related thermodynamic parameters such as βa, $L_f$ and τ at various concentrations and at 298K temperature in the Acetonitrile in 1,4 Dioxaneshows the variation - linear. Weak intermolecular interactions are confirmed in the systems investigated.This provides useful information about solute solvent interactions in the mixture as existing in the liquid system.

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