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EFFECT OF SOLVENT ON ACOUSTIC PARAMETERS OF P-TOLUIDINE AT DIFFERENT TEMPERATURES.

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Abstract:

We are aware that a plethora of knowledge regarding molecular behavior and intermolecular interactions in various solvents can be obtained from ultrasonic studies. With p-Toluidine at various temperature in different solvents we have study interactions existing in it. Recently, the molecular interactions existing in the solution have been studied using an ultrasonic velocity instrument. The thermo acoustic related physical parameters like "Velocity" (U), "density" (ρ), "viscosity" (η), "adiabatic compressibility" (βad), "intermolecular free length" (Lf) and "specific acoustic impedance" (Z) are evaluated. Ultrasonic velocities, densities of p-Toluidine in ethanol and methanol were calculated in both the solvents. These parameters were useful to predict the intermolecular interaction reactivity in solution

Key words: Molecular, ethanol, methanol, interaction, reactivity, ultrasonic

Introduction:

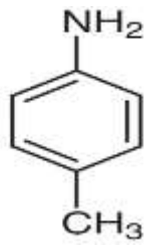
It is clear that knowledge of the molecular interactions in solution has benefited from an awareness of the acoustic properties of liquids. An ultrasonic measurement gives the idea about the interactions between molecules in binary mixtures. The ultrasonic interferometry technique is used to study properties of liquids. Studying the kind and intensity of molecular interactions between liquids is also beneficial. In the field of molecular sciences, ultrasonics is crucial. Regarding interactions between ions, dipoles, hydrogen bonding, and solute-solvent interactions, ultrasonic velocity, density, and viscosity offer highly useful information. The most straightforward method for examining different thermodynamic ultrasonic parameters is through liquid mixes.

Since ultrasonic and other related thermoacoustic characteristics provide significant information about molecular structures, molecular packing, and intra- and intermolecular interactions, ultrasonics is the most exciting area of scientific inquiry for researchers.

The groups which increase the rate of a reaction is called activating. Deactivating groups are groups which decrease the rate of a reaction. Groups that contribute electrons to the ring's substitutes are known as activating groups. Groups on the ring known as substitutes are those that deactivate by withdrawing electrons. P-Toluidine is an aromatic amine with the chemical formula C_7H_8N. The amino group is electron donating and hence it strongly activates the benzene ring.

Due to reactivity of it, in the manufacture of dyes, pharmaceuticals, and as a reagent in organic synthesis- toluidine is used. It is toxic and can be harmful if ingested, inhaled, or absorbed through the skin.

In our study, we try to predict reactivity and interaction present in ethanol and methanol at various temperatures.



p-Toluidine

Experimental

One easy and accurate method for determining the ultrasonic velocity in liquids with great precision is to use an “ultrasonic interferometer”. A simple, accurate instrument that produces reliable and consistent findings is the ultrasonic interferometer, which can measure the velocity of ultrasonic sound in a liquid medium with great precision.

The precise measurement of the medium's wavelength (λ) serves as the foundation for the ultrasonic velocity (U) calculation method. ultrasonic waves generated in the cell with a specified frequency (f). The velocity (U) can be obtained from the relation:

“Velocity = Wavelength × Frequency”

$U = \lambda \times f$

AR grade liquids were utilized. Temperature measurements for this study were taken at 303 K. By using an electrically digitally driven water bath with a consistent temperature to circulate water through to the steel cell, the temperature of the liquid mixture was maintained. Ultrasonic velocity measurements were performed at a frequency range of 2MHz with an accuracy of ±0.01m/s using an ultrasonic interferometer “Mittal type, Model F-18”. The measurement was carried out by specific density bottle with accuracy of ± .1 kgm^{-3}. The viscosity measurements were done by Ostwald Viscometer. The viscosity of an unknown liquid mixture is calculated using the time required for the mixture and distilled water.

“Ultrasonic velocity” (U), “density” (ρ) and “viscosity” (η) used to determine various physical parameters:

1. **“Adiabatic Compressibility” (β):**

The ratio of the volume drop to the pressure increase in the absence of any external or internal heat flow is referred to as the Adiabatic Compressibility.

$$\beta = 1/ \rho v^2$$

2. “Specific Acoustic Impedance” (Z):

The the relationship between the complex amplitude of sound pressure and a given vector component of the related ultrasonic velocity.

$$Z = U \rho$$

3. “Intermolecular free length” (Lf):

The intermolecular free length is the duration of time a sound wave travels across the surfaces of two neighbouring molecules. The molecule interaction free length must decrease as the ultrasonic velocity rises as a result of concentration increases. It can be related to ultrasonic velocity and density:

$$Lf = K/ \rho U^{1/2}$$

Result and Discussion:

The values of p-toluidine's density, viscosity, and ultrasonic velocity in different solvents and temperatures are shown in Table 1. In addition, Table 2 displays other thermodynamic features such as particular acoustic impedance, adiabatic compressibility, and intermolecular free length.

Table 1: Adiabatic compressibility, specific acoustic impedance, density, ultrasonic velocity, and intermolecular free length of p-toluidine in ethanol at 298 K.

Concentrations M	Ultrasonic Velocity m/s	Density Kg/m^3	Adiabatic Compressibility $*10^{-10}$	Acoustic Impedance$*10^6$ Kgm^2s^{-1}	Intermolecular free length A°
0.001	**1280.25**	**825.12**	**7.394**	**1.056**	**0.543**
0.01	**1284.69**	**827.54**	**7.326**	**1.062**	**0.541**

0.1	**1293.63**	**829.23**	**7.206**	**1.072**	**0.536**
303K					
0.001	**1284.96**	**823.60**	**7.353**	**1.058**	**0.542**
0.01	**1289.69**	**824.83**	**7.288**	**1.063**	**0.539**
0.1	**1297.73**	**826.10**	**7.187**	**1.072**	**0.536**

Table 2: Acoustic Parameters of Methanol at **298 K**.

Concentrations M	**Ultrasonic Velocity m/s**	**Density Kg/m^3**	**Adiabatic Compressibility* 10^{-10}**	**Acoustic Impedance*1 0^6 Kgm^{2s-1}**	**Intermolecular free length*10^{-10} A^0**
0.001	**1260.96**	**820.17**	**7.668**	**1.034**	**0.553**
0.01	**1264.60**	**821.02**	**7.593**	**1.038**	**0.551**
0.1	**1271.05**	**823.47**	**7.516**	**1.046**	**0.548**
303K					
0.001	**1270.49**	**816.12**	**7.591**	**1.036**	**0.551**
0.01	**1276.23**	**817.46**	**7.510**	**1.043**	**0.548**
0.1	**1282.77**	**818.08**	**7.428**	**1.049**	**0.545**

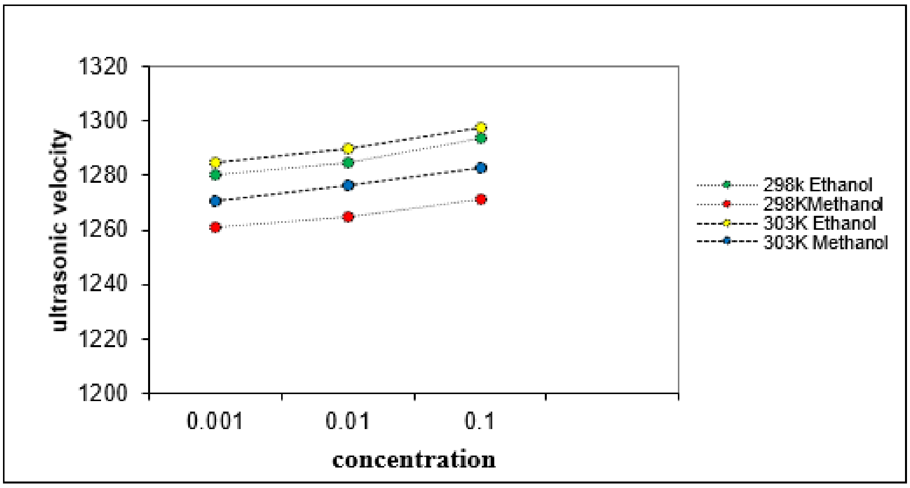


Fig.1: ultrasonic velocity in different solvents, temperatures, concentrations

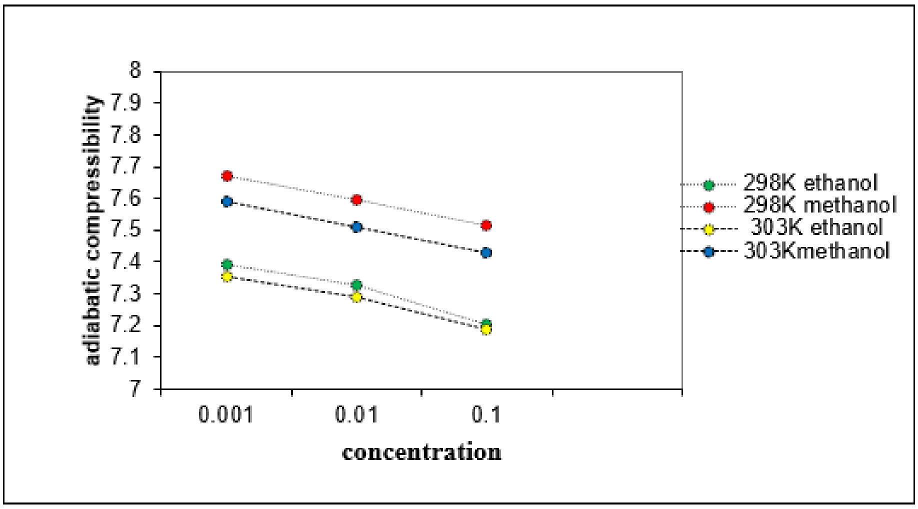


Fig2 Adiabatic compressibility in different solvents, concentrations , temperatures

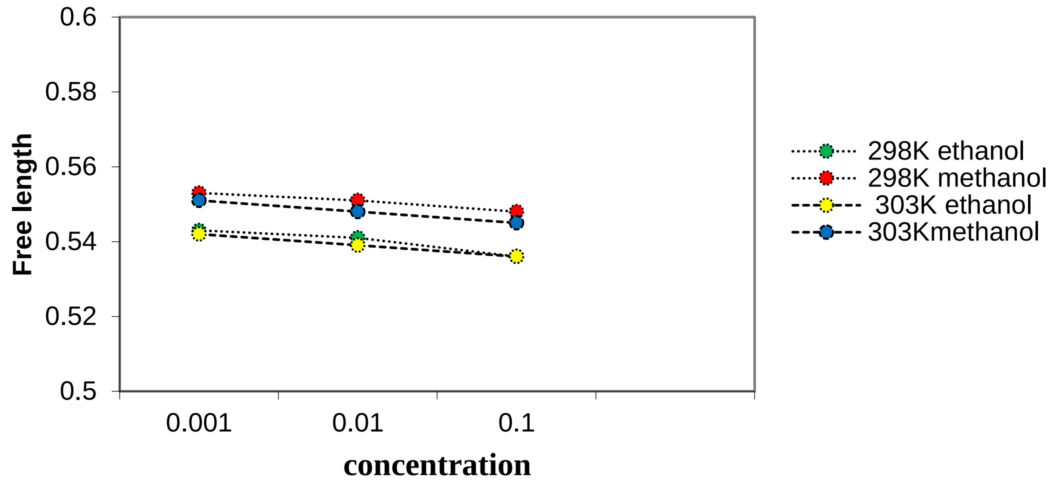


Fig.3 Free length in different solvents, concentrations, temperatures

From Table 1&2, fig1 Ultrasonic velocity increase with rise in concentration in each solvent suggests strong solute-solvent interaction in the solution. But in ethanol it has high value compare to methanol because of strong hydrogen bonding ethanol and p-toluidine. Ethanol has high bulk modulus than methanol and hence more ultrasonic velocity.

Compressibility measures how much liquid compress. Low value of adiabatic compressibility suggests more compression in the solution resulting strong interaction. From fig2, as concentration increases in both solvents compressibility decreases but in ethanol is lower intimate that formation of hydrogen bond is more and more aggregation of solute in solvent results strong interaction.

From fig 3 Intermolecular free length decreases in ethanol as compare to methanol with rising concentration suggesting strong solute solvent interaction existing in the solution. Strong interactions exist in the solution, resulting in a higher specific acoustic impedance in ethanol shoes.

Conclusion:

Ultrasonic velocity is much more in ethanol than methanol of p-toluidine is due low compressibility. Adiabatic compressibility, intermolecular free length has lower value in ethanol as compared to methanol. Specific acoustic impedance is much more in ethanol implies strong solute-solvent interaction in ethanol as compared to methanol.

Higher concentrations result in lower adiabatic compressibility and intermolecular free length as well as increased ultrasonic velocity, density, and acoustic impedance, according to the findings. These findings imply that the material's structural and acoustic properties are significantly influenced by solvent change which could be crucial at 298 K and 303 K underscore the sensitivity of acoustic properties. These findings contribute to a deeper understanding of molecular interactions in solvents and have potential implications for applications involving acoustic measurements and material characterization.

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