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Thermo Acoustic Study Of Benzamide In Different Solvents At 303K

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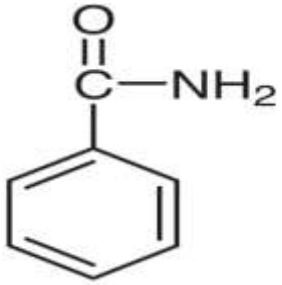
Abstract:
This paper discusses an ultrasonic interferometric analysis of Benzamide in ethanol, methanol, Acetone and Diethyl ether at a temperature of 303K to understand the solute solvent interactions as well as the acoustic behaviour of the solution. Consequently, with the use of ultrasonic interferometry, we determined the velocity of sound and the other acoustic parameters in both solvents. This study shows that benzamide has different ultrasonic behaviour in pure ethanol as compared to methanol and it is caused by the variation in structural and dynamic characteristics of ethanol solvent. In particular, the ultrasonic velocity and attenuation coefficients were used to acquire information on the molecular forces and solvation processes occurring in each solvent system. The observed changes in the acoustic parameters are explained with reference to solvent polarity, hydrogen bonding and molecular interactions and gives a scientific insight of the molecular interaction of benzamide with ethanol and methanol at a specific temperature. These results should therefore prove useful with regard to the best means of employing benzamides in a variety of industrial and scientific processes.

Keywords: Benzamide, Ethanol, Methanol, Acoustic, Solute-solvent interactions, Ultrasonic velocity,

Introduction:
Knowledge of solute-solvent interactions play a vital role in the development of theoretical as well as the applied chemistry. Benzamide a well-characterized organic compound used “pharmaceutical intermediate agrochemicals”, and reagent in organic synthesis represents a good system for the study of these interactions. The studies of solvents effects and behaviour of benzamides can give the information about solvation dynamics, interactions, and molecular solvents. Ethanol and methanol, two alcoholic solvents of extensive use, offer quite a different environment which has the potential of altering solute properties due to differences in polarity and hydrogen bonding.
Ultrasonic interferometry is one of the most sensitive techniques for measuring velocity of sound and its attenuation in a solution. These acoustics properties are closely associated with the salvation and molecular association interactions between solute and solvent molecules and therefore, Ultrasonic studies are found highly useful for the study of solvation processes [1](Chowdhury et al., 2019). From variations in ultrasonic velocity and attenuation coefficients, one can get structural and dynamic characteristics of solute-solvent interactions [2](Gonçalves et al., 2021).
The solubility and interaction behaviour of benzamides have been proved in earlier works with different solvents. For example, studies about benzamide sol:
The present findings stress on the impact of the nature of the solvent in the solubility of the benzamide solute [3](Sinha et al., 2018). However, fine work that uses techniques such as ultrasonic interferometry to investigate such interactions has not been well done especially in ethanol and methanol.
Ethanol and methanol are special because of their hydrogen bonding and polarity although they are both known to be polar solvents. Ethanol, with moderate polarity and higher potential of hydrogen bonding than methanol, differs from methanol, which is polar, slightly smaller, but possesses a different hydrogen bonding characteristic [4] (Kumar et al., 2020). These differences are expected to influence solvation shell of benzamide and its pattern of solubility and interaction in different solvents.



This research uses ultrasonic interferometry, to investigate the solute benzamide in ethanol and methanol solvents at a temperature of 303 K, through the determination of velocity of sound and attenuation coefficients.

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❖ The ultrasonic velocity and attenuation in benzamide solutions in the different solvent were studied. These measurements showed how solvent environment influences the acoustic characteristics of the solution.
❖ A study was made of how the properties of the solvent affected the behaviour of benzamide in interaction processes. Here it will be involved understanding the role of solvent polarity on the observed ultrasonic behaviour as well as that of hydrogen bonding.
❖ Further the knowledge in solute-solvent interaction by providing the appropriate acoustic data information. The presented research contributes to the enhancement of the understanding of how various solvents affect the changes in benzamide solutions' characteristics.

Taking a closer look at the behaviour of benzamide activating and deactivating in ethanol and methanol, there is need to investigate in detail the solute-solvent interactions and its impact on the properties of the solute. Benzamide, which is widely used in the pharmaceuticals as well as exhibiting a wide variety of chemical properties has shown disparate solvation behaviour when dissolved in ethanol and methanol.

Ethanol is a polar solvent which also has a high propensity toward hydrogen bonding as a result of it containing a hydroxyl R group. This property may increase ability to solvate solutes that can capable of forming hydrogen bonds or possessing polar groups. Here, benzamide has the functional group of amide that allows its capability of forming hydrogen bonding which helps in the stabilization of the solute through the solute solvent interactions. This stabilization can result to what is commonly referred to as "activating behaviour" whereby the reactivity or solubility of the solute increases as a result of interactions with the solvent.

In ethanol the intermolecular force is Hydrogen bonding formed between the hydroxyl group of ethanol and the amide hydrogen of benzamide which may lead to a better solubility and reactivity of benzamide in reactions where the solvent is an influential factor. This activating behaviour is accompanied by a rise in ultrasonic velocity and in the changes on attenuation, which typifies the active interaction between the solute and solvent [5] (Kumar et al., 2020). In the case of benzamide solvents are capable of forming hydrogen bonds with the solute molecules arguably altering free energy thereby improving solubility or even effecting reactions kinetics-remodeling.

Methanol and a polar solvent with hydrogen-bonding ability are different from ethanol structural and bonding approach. This was attributed to methanol's comparatively smaller molecular size and fewer hydrogen bonding sites as compared to ethanol which led to a lesser extent of solvation network. This can result in what is described as deactivating behaviour among some solutes. The present findings hence suggest that the interaction between benzamide and methanol as solvent may be relatively less or of less favourably compared to ethanol. Methanol has lesser capability of hydrogen bonding and this may imply that benzamide and the solute molecules would be less stabilized.

In methanol, there are different solute–solvent interactions of the ultrasonic velocities and attenuation parameters when compared to ethanol [6](Gonçâlves et al., 2021). When solvation is not as efficient solubility and reactivity of benzamides decrease. This deactivation behaviour can be must be due to the lowered interaction strength of methanol molecules with benzamide and less-number of hydrogen bonds favourable to the solute stability in the solution.

These findings are a clear indication that solvent characteristics play a crucial role in the determination of solute properties as shown by the activating and deactivating behaviour of benzamide in ethanol and methanol. Most especially, the demonstrated ability of ethanol to interact strongly through hydrogen bonding raises solubility and interaction dynamics with benzamide to activating effects. On the other hand, methanol has limited hydrogen bonding interactions which lead to several deactivating impacts. [8]

All these behaviours are important in applications where solubility and reactivity of solute are important from formulation point of view for instance in pharmaceutical formulations or chemical synthesis. The knowledge of how these various solvents affect these properties by solute-solvent interactions renders information for the processes and applications of benzamide and analogous compounds beneficial. [9]

Although benzamide has an amide functional group that comes with carbonyl carbon less electrophilic due to resonance between carbonyl and nitrogen while containing carbonyl group, acetone in general, does not pose threat to reactions involving benzamide as it does not have highly reactive functional groups. Its deactivating nature can be explained because acetone does not interact with the benzamide through proton transfer or large co-ordination.

Diethyl ether, being a non-polar solvent and having dielectric constant higher than acetone is even less reactive than acetone. With benzamide, the inactivity of diethyl ether in deactivation is so clear since the substance does not chemically interfere with the amide group in any way. Diethyl ether has no specific interactions with the benzamide molecule or hydrogen bonding or any reaction with it at the typical conditions hence acting like an inert solvent. This is why diethyl ether is used in reaction that require a solvent which does not interfere with the functional groups of benzamide.

Benzamide suppresses reactions involving acetone and diethyl ether because they are not potent enough to function as a nucleophile or an electrophile with the given molecule.

Diethyl ether is less reactive than acetone which is a non-polar solvent having low dielectric constant. Diethyl ether does not deactivate the benzamide group hence it deactivating ability is very conspicuous because it does not have any chemical activity with the amide group. Normally, diethyl ether cannot take part in an interaction such as a hydrogen bond or reaction of any kind with the benzamide molecule, so all that it can be is a passive solvent. Diethyl ether does

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not alter or distort the functionality groups of benzamide hence it is mostly used in reaction wherein an environment that does not interfere with the functionality group is required because of this characteristic.

Materials and Methods:

An ultrasonic interferometer is a straightforward tool for precisely determining ultrasonic velocity in liquids. The high-precision measurement of ultrasonic sound velocity in a liquid medium is made possible by an ultrasonic interferometer, a simple device that yields accurateandtrustworthydata.

The exact measurement of the medium's wavelength (λ) serves as the foundation for the ultrasonic velocity (U) computation method. Within the cell, ultrasonic waves of known frequency (f) are created. The relationship can be used to get the velocity

Wavelength X Frequency=Velocity

AR-grade chemical 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. With an accuracy of ±0.01m/s, ultrasonic velocity measurements were conducted at a frequency range of 2MHz using an ultrasonic interferometer (Mittal type, Model F-18). A specific density bottle was used to carry out the measurement, which had an accuracy of ±.1 kgm^{-3}. Ostwald Viscometer was used to measure viscosity. The viscosity of an unknown liquid mixture is calculated using the time required for the mixture and distilled water.

Theory:

Here we have calculated ultrasonic velocity, density, and viscosity to determine some ultrasonic acoustic parameters such as:

1. **Adiabatic compressibility:** $\beta = 1 / v^2.d$
2. **Specific Acoustic Impedance:** $Z = vs .ds$
3. **Intermolecular Free Length:** - $Lf = K\sqrt{\beta s}$

Result and Discussion:

Tables display the density, viscosity, and ultrasonic velocity values for benzamide in various solvents at 303K. Tables also display the thermodynamic features such as specific acoustic impedance, adiabatic compressibility, and intermolecular free length. Also, we presented some relevant data in tables and displayed graphically of benzamide.

Ethanol					
Concentrations M	**Ultrasonic Velocity m/s**	**Density Kg/m^3**	**Adiabatic Compressibility* 10^{-10}**	**Acoustic Impedance*10^5 Kgm^2s^{-1}**	**Intermolecular free length A^o**
0.001	**1240.23**	**803.4**	**8.09**	**9.964**	**0.569**
0.01	**1244.08**	**804.6**	**8.03**	**10.009**	**0.567**
0.1	**1256.69**	**805.14**	**7.86**	**10.118**	**0.561**
Methanol					
0.001	**1210.10**	**799.47**	**8.54**	**9.674**	**0.569**
0.01	**1212.89**	**800.3**	**8.49**	**9.706**	**0.567**
0.1	**1214.16**	**801.12**	**8.43**	**9.742**	**0.561**
Acetone					
0.001	**1166.24**	**786.14**	**9.35**	**9.168**	**0.612**
0.01	**1172.40**	**788.06**	**9.23**	**9.239**	**0.608**
0.1	**1182.54**	**789.62**	**9.06**	**9.337**	**0.602**
Diethyl Ether					
0.001	**1148.59**	**759.19**	**9.98**	**8.719**	**0.632**
0.01	**1152.32**	**760.3**	**9.90**	**8.761**	**0.629**
0.1	**1168.61**	**762.30**	**9.60**	**8.908**	**0.620**

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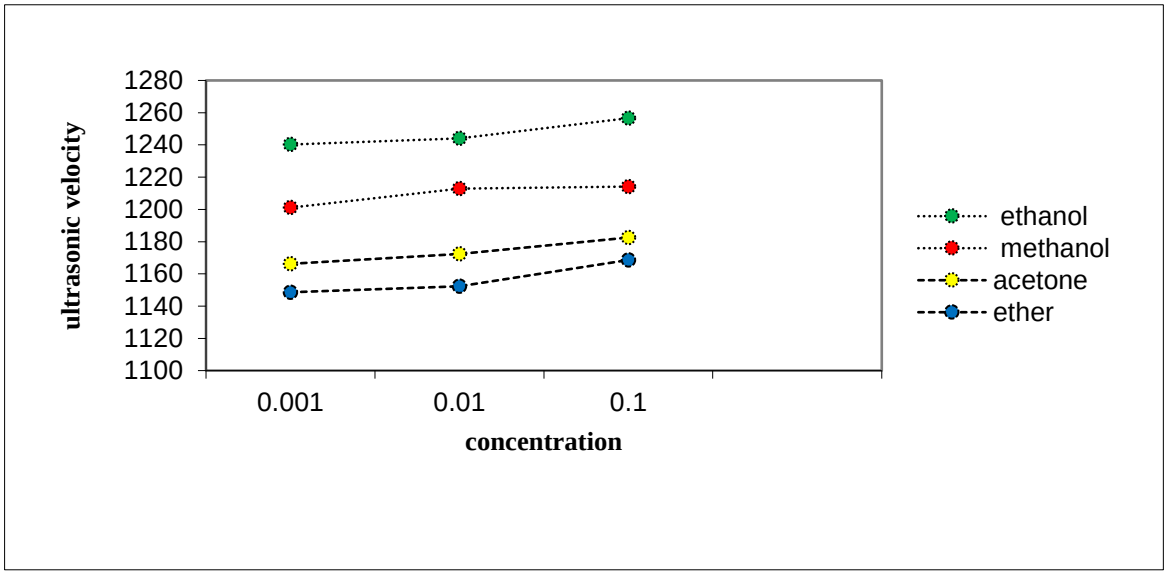

Fig.1: Ultrasonic Velocity in different solvents

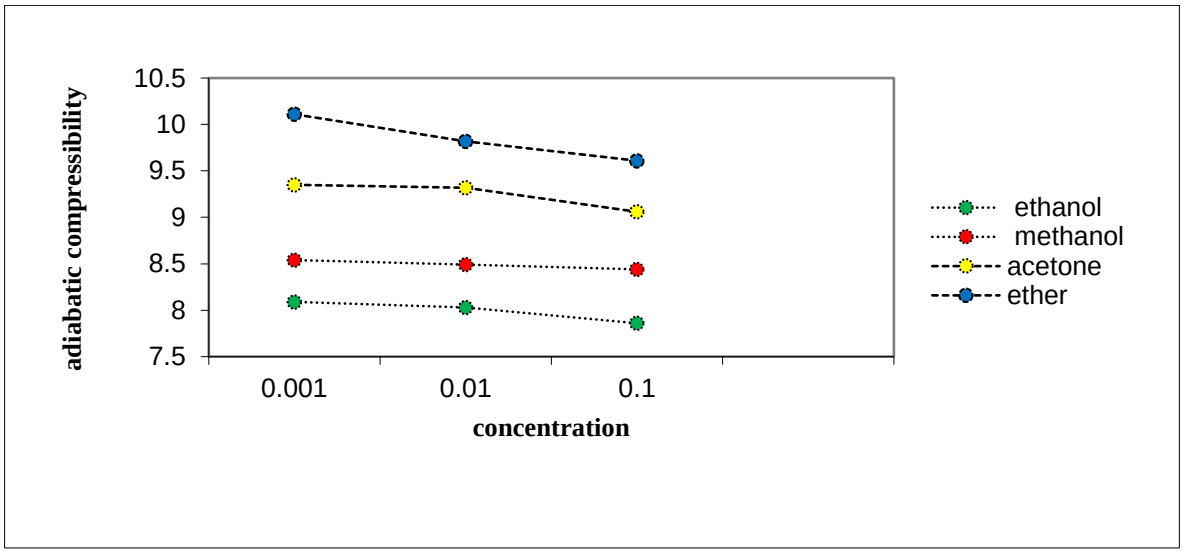

Fig. 2: Adiabatic Compressibility in various solvents

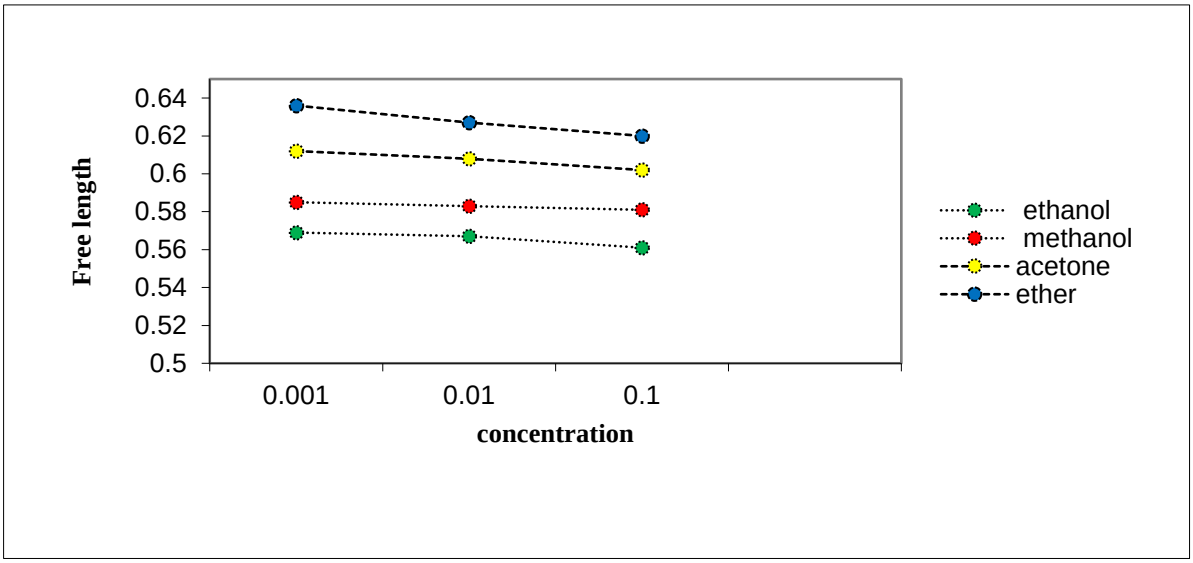

Fig 3 : Intermolecular Free length in various solvents

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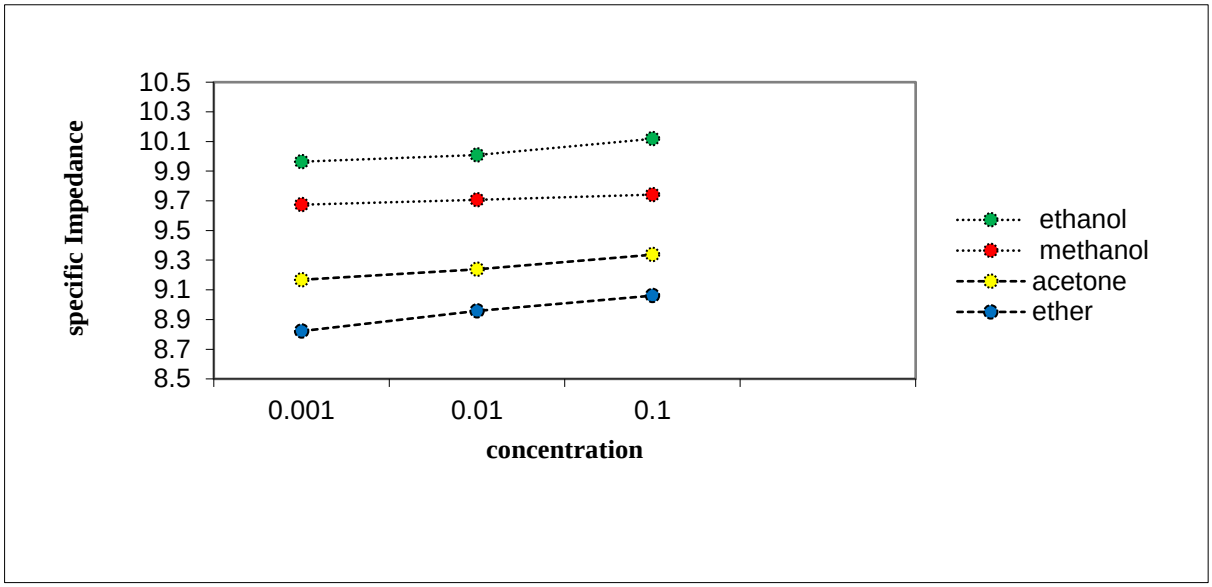

Fig.4: Specific Impedance in different solvents

Fig 1 and table1 shows that ultrasonic velocity of benzamide is high in ethanol at 303K as compared to listed solvents as this solution has relatively low viscosity which speed up the sound waves. Molecular structure of ethanol allows more efficient transmission of sound waves that strengths the compact structure of solute in ethanol resulting into strong molecular interaction between benzamide in ethyl alcohol

Compressibility depends upon pressure volume relationship. Fig.2 reflects least value of adiabatic compressibility of benzamide in ethanol at 0.1M solution indicates compactness structure which enhances strong hydrogen bonding in the solution signifies strong interaction present between benzamide and ethanol.

Fig3 reveals that benzamide has minimum value of intermolecular free length in ethanol implicates solute and solvent molecules are closer together reducing free length and potentially increases ultrasonic velocity and hence strong solute solvent interaction exhibit in the solution of ethanol than methanol, acetone and ether. Impedance in ethanol is more denotes hydrogen bonding is strong between benzamide and ethanol shows strong molecular interaction in it.

Conclusion:

In our study we found the heightens values of ultrasonic velocity, specific impedance and lowest of adiabatic compressibility, intermolecular free length in benzamide + ethanol against methanol acetone and diethyl ether implies strong molecular interaction in ethanol due to strong hydrogen bonding , more compact structure of ethanol solution.The deactivating group in bezamide makes it less reactive towards chemical reaction so elevates the interaction in ethanol relative to listed solvents.

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