Thermo-Acoustic Behavior of Cypermethrin in Acetone at different temperature.

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Abstract: Ultrasonic velocity measurements are an effective physicochemical tool for investigating molecular interactions in liquid solutions. In the present study, ultrasonic velocity of cypermethrin dissolved in acetone has been measured at different molar concentrations over varying temperature range. The experimental results reveal a systematic dependence of ultrasonic velocity on both concentration and temperature. The observed variations are interpreted in terms of solute–solvent interactions, changes in molecular packing and thermal effects. The study demonstrates that ultrasonic techniques provide valuable insight into the thermo-acoustic behavior of pesticide solutions and contribute to understanding the molecular interactions of cypermethrin in polar aprotic solvents such as acetone.

***Index Terms* - Cypermethrin, Ultrasonic velocity, Acetone, Temperature effect, Molecular interactions.**

INTRODUCTION

Cypermethrin is a synthetic pyrethroid insecticide widely used in agricultural industry due to its high insecticidal efficiency and chemical stability.[1] Its physicochemical behavior in organic solvents is of considerable interest in formulation development, residue analysis, and environmental transport studies. Ultrasonic velocity measurements have been extensively employed to probe intermolecular interactions in liquid systems. [2-3]. The propagation of ultrasonic waves through a medium depends on the elastic and structural properties of the liquid, which are influenced by solute–solvent interactions, molecular association, and temperature effects. [4-5] Therefore, ultrasonic velocity serves as a sensitive indicator of changes in solution structure and interaction strength. Acetone, a polar aprotic solvent with moderate dielectric constant and low viscosity, is commonly used for dissolving hydrophobic pesticides such as cypermethrin. Studying the ultrasonic behavior of cypermethrin in acetone provides insight into molecular interactions governed primarily by dipole–dipole forces and dispersion interactions. Although ultrasonic studies have been reported for cypermethrin in other organic solvents, systematic investigations in acetone over a wide temperature range are not studied yet. The present work aims to fill this gap by examining the effect of concentration and temperature on ultrasonic velocity of cypermethrin solutions in acetone.

RESEARCH METHODOLOGY

Materials

- Cypermethrin (sigma-Aldrich, Merck Group, Germany) analytical grade (purity ≥ 95%) was used as the solute without further purification.
- Acetone of analytical reagent (AR) grade was employed as the solvent.
- Ultrasonic Interferometer: F-81S, Mittal Enterprises, New Delhi, India with temperature controller was employed for precise measurement
- Calibration Standard: Pure Acetone solution used for calibration.

Sample Preparation

- Cypermethrin solutions were prepared at molar concentrations of 0.002 and 0.010 mol dm^{-3} using standard volumetric techniques. Appropriate amounts of cypermethrin were accurately weighed using a digital analytical balance (accuracy ±0.1 mg) and dissolved in acetone in calibrated volumetric flasks. The prepared solutions were stored in airtight containers to prevent solvent evaporation.
- Temperature Control: All measurements were conducted in range of 25o C to 45o C.

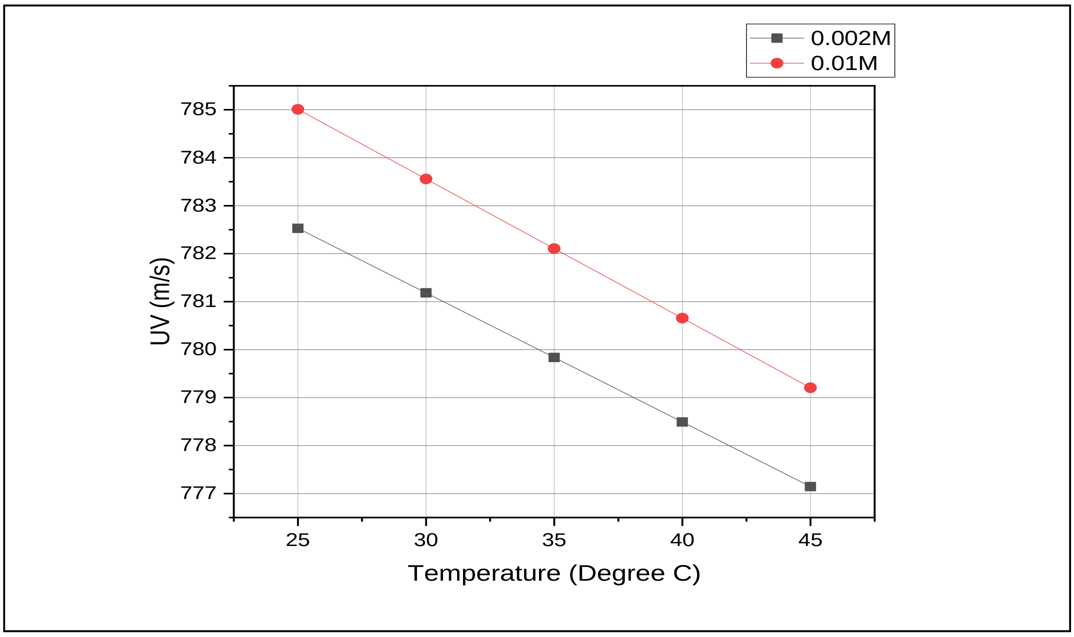
Experimental

The ultrasonic interferometer cell was thoroughly cleaned and dried before introducing each solution. The prepared cypermethrin solution was poured into the cell, ensuring the absence of air bubbles, which could affect the accuracy of measurements. Ultrasonic velocity measurements were first performed for pure acetone by using ultrasonic interferometer working at 1 MHz (accuracy ± 0.05%) at each temperature to ensure proper calibration of the instrument.[6] Subsequently, measurements were carried out for cypermethrin solutions of 0.002 and 0.010 mol dm^{-3}concentration at the same temperature. The procedure was repeated for all temperatures studied. This procedure is performed in triplicate and average value is taken as a reading for sample at corresponding temperature range of 25^{o} C to 45^{o} C which are given in Table No.1.

Table No.1.
Ultrasonic velocities(M/s) of cypermethrin at different temperatures(°C) and Concentration (mol dm⁻³).

Sr.No.	Temperature (°C)	Ultrasonic velocity (m s^{-1}) for (0.002 mol dm^{-3})	Ultrasonic velocity (m s^{-1}) for (0.010 mol dm^{-3})
1	25	782.528	785.008
2	30	781.18225	783.55725
3	35	779.8365	782.1065
4	40	778.49075	780.65575
5	45	777.145	779.205

Graph No.1
Temperature Vs Ultrasonic Velocity



RESULTS AND DISCUSSION

Ultrasonic velocity measurements of cypermethrin solutions in acetone were carried out at concentrations of 0.002 and 0.010 mol dm^{-3} over the temperature range 25°C – 45 °C. The results show a systematic decrease in ultrasonic velocity with increasing temperature for both concentrations which can be attributed to enhanced thermal agitation and the consequent weakening of intermolecular cohesive forces in the solution. At any fixed temperature, the ultrasonic velocity was found to be higher at increased concentrations of cypermethrin, reflecting a concentration dependent modification of the acoustic properties of the solution. This behavior suggests the presence of stronger solute–solvent interactions between cypermethrin molecules and the acetone medium. The increase in ultrasonic velocity with concentration may be attributed to enhanced molecular association, leading to a more structured and less compressible liquid environment. Such interaction induced structural changes influence the elastic nature of the solution and facilitate more efficient propagation of ultrasonic waves. The present study provides useful experimental data that may contribute to a better understanding of the physicochemical behavior of cypermethrin in organic solvents and can support further acoustic and thermodynamic investigations of similar agrochemical systems.

CONCLUSION

The ultrasonic investigation of cypermethrin in acetone confirms that acoustic measurements are highly responsive to changes in the elastic and structural characteristics of the solution. This study highlights the effectiveness of ultrasonic velocity measurements as a non-destructive and reliable approach for assessing molecular interactions in pesticide–solvent mixtures. Future work may include the determination of additional acoustic parameters such as adiabatic compressibility, intermolecular free length, acoustic impedance, and relaxation strength to obtain deeper insight into the nature and strength of molecular interactions.

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