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# Determination of Acoustical Parameters In Binary Liquid Mixture of Diethyl Ether And Malathion by Ultrasonic Measurement

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**ABSTRACT**
*Binary liquid mixture find practical applications in most chemical processes, their properties are less known. Derived parameters from ultrasonic speed measurements provide qualitative information regarding the nature and strength of interaction in liquid mixtures. Organophosphate pesticides such as malathion have been used as alternatives to dichloro-diphenyl-trichloroethene (DDT) and other chlorinated hydrocarbon pesticides. Diethyl ether is also used as solvent in various organic syntheses. Thus malathion and diethyl ether mixed solvents would enable us to have a large no. of solvents with appropriate physic-chemical properties, which can be used for a particular chemical process. Therefore present study was undertaken in order to have deeper understanding of the intermolecular interaction between the components of the above binary liquid mixture.*

**Keywords:** Organophosphorus pesticides, Acoustical parameters, Molecular interaction.

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## INTRODUCTION

Pesticides used in pre- and postharvest treatments to control diseases of fruits and vegetables may persists over the season and appear in processed product for human, consumption, such as fruit juice, which are widely consumed, particularly by children’s [1-3]. Several pesticides groups, fungicides [4-6], pyrethroids [7], and triazine herbicides [8] have been determined in fruit juice. Organophosphorus pesticides (such as – malathion, diazinon, ethion etc.) have also been studies because some of them are extensively used and have a high solubility in water, the main component of fruit juice.

Organophosphorus pesticides are generally determined by gas chromatography with flame-photometric detection (FPD) [9-11], or nitrogen-phosphorus detection (NPD) [12], although HPLC with diode array detection (2l) or coupled with tandem mass spectrometry [13] has also been applied. Organophosphate pesticides such as malathion have been used as alternatives to dichloro-diphenyl-trichloroethene (DDT) and other chlorinated hydrocarbon pesticides. However the Organophosphorus pesticides are not rapidly degraded in natural waters. At 20oC and ph 7.4, malathion has a hydrolytic half life of 108 days and its toxic metabolite, paradoxes has a similar half life of 144 days [14].

The study of acoustical parameters of binary liquid mixtures has provided to be a useful tool in elucidating the structural interactions components [15-19]. Many researchers have shown that important and fundamental role of molecular details of the solvent species to determine the specific interactions which are responsible for macroscopic thermodynamic and other related properties in non-electrolytic solvents.

Thus the knowledge of the structure of the mixed solvents systems becomes an essential prerequisite to interpret and to understand the interaction patterns between ions, ions-pairs, and ionic aggregates, and bulking solvent molecules. In principle, the interaction between the molecules can be established from the study of the characteristics, abrupt departure from ideal behavior of some physical properties like volume, compressibility, viscosity etc.

In this paper, the acoustical parameters determined in the binary mixture of malathion and diethyl ether and the type of interaction in this system have been studied and behavior have been explained on the basis of intermolecular force.

In this study, the density, ultrasonic velocity and viscosity, values of pure diethyl ether, and malahoin and those of their binary mixtures over the entire composition range have been measured and reported at 303K and 308K, respectively.

The variation of these properties with composition and temperature of the binary mixtures are studied in terms of molecular interactions between unlike molecules of the mixtures.

## RESULTS AND DISCUSSION

Various acoustical parameters such as isentropic compressibility (β), Intermolecular free length ($L_f$), free volume ($V_f$), and specific acoustical impedance (Z), were calculated using the experimental data of ultrasonic sound velocity, density and viscosity by the following equations (1-5).

$$\beta = 1/U^2\rho \qquad (1)$$

$$L_f = kT(\beta)^{1/2} \qquad (2)$$

$$V_f = (M_{eff}U/\eta k)^{3/2} \qquad (3)$$

$$Z = U\rho \qquad (4)$$

$$\tau = 4/3\beta\eta \qquad (5)$$

Where $kT$ is the temperature dependent constant having a value $199.53 \times 10^{-8}$ in MKS system , k is the constant equal to $4.28 \times 10^9$ in MKS system, independent of temperature of all liquids, and all the notations having the usual meanings. The experimental and the calculated data for two binary liquids mixtures are listed in Table-1 to Table-4.

From the experimental data, it is observed that decrease in density and viscosity with the increase in the mole fraction of diethyl ether and increase in the temperature range indicates decrease in the intermolecular force due to increase in the thermal energy of the system. This cause an expansion in volume and hence increase in free length [20-21].

The results of variation in intermolecular free length deviation of binary system consisting of malathion with diethyl ether at temperature of 303oK and 308oK shows positive and negative deviations over the entire range of mole fraction. The free length of the mixture strongly depends on the entropy of the mixture which is related with liquid structure and enthalpy. Consequently with the molecular interaction between the components of the mixtures. Therefore the free length deviations depend on molecular interaction as well as size on the molecules [22].

With the increase in temperature there occur structural rearrangements as well as a result of interaction leading to comperatively more ordered states. Therefore ultrasound speed increase with increase in temperature [23]. Isentropic compressibility and the specific acoustic impedance decreases with the mole fraction. It is observed that decrease in free energy favours the formation of products after reaction [24]

**Table-1:- Value of U, ρ, η and β at $303^0$K for diethyl ether and malathion binary liquid mixture**

| Mole fraction (X) | Ultrasound Velocity (U) m/s | Density gm/mol | Viscosity (η) x $10^3$N.s.m$^{-2}$ | Adiabatic compressibility (β)x $10^{10}$ cm$^2$/dyne |
|---|---|---|---|---|
| 0.0000 | 1288 | 1.0238 | 1.6920 | 58.88 |
| 0.0417 | 1290 | 0.8339 | 2.9175 | 72.06 |
| 0.0893 | 1301 | 0.8224 | 2.8398 | 71.84 |
| 0.1439 | 1313 | 0.8141 | 2.7430 | 71.25 |
| 0.2072 | 1325 | 0.8063 | 2.6182 | 70.64 |
| 0.2817 | 1337 | 0.7986 | 2.5215 | 70.05 |
| 0.3703 | 1349 | 0.7922 | 2.3361 | 69.37 |
| 0.4778 | 1361 | 0.7849 | 2.2102 | 68.78 |
| 0.6107 | 1373 | 0.7779 | 2.0165 | 68.19 |
| 0.7792 | 1385 | 0.7721 | 1.8097 | 67.52 |
| 1.0000 | 1401 | 0.7684 | 1.3024 | 66.30 |

**Table-2:- Value of $V_f$, $L_f$, Z, and τ at $303^0$K for diethyl ether and malathion binary liquid mixture**

| Free Volume ($V_f$) x $10^7$/m$^3$.mol$^{-1}$ | Intermolecular Free Length ($L_f$) x $10^{11}$/m | Specific impedance (C.G.S.) | Shear's relaxation time (τ) x $10^{-9}$sec. |
|---|---|---|---|
| 62.05 | 0.5356 | 1.3187 | 1.33 |
| 33.07 | 0.5348 | 1.0757 | 2.80 |
| 41.86 | 0.5326 | 1.0699 | 2.72 |
| 53.54 | 0.5303 | 1.0689 | 2.61 |
| 69.95 | 0.5281 | 1.0683 | 2.47 |
| 89.44 | 0.5255 | 1.0677 | 2.36 |
| 121.94 | 0.5233 | 1.0687 | 2.16 |
| 161.62 | 0.5210 | 1.0682 | 2.03 |
| 227.28 | 0.5184 | 1.0681 | 1.83 |
| 329.74 | 0.5138 | 1.0694 | 1.63 |
| 674.92 | 0.5356 | 1.0765 | 1.15 |

**Table-3:- Value of U, ρ, η and β at $308^0$K for diethyl ether and malathion binary liquid mixture**

| Mole fraction (X) | Ultrasound Velocity (U) m/s | Density gm/mol | Viscosity (η) x $10^3$N.s.m$^{-2}$ | Adiabatic compressibility (β)x $10^{10}$ cm$^2$/dyne |
|---|---|---|---|---|
| 0.0000 | 1278 | 1.0028 | 1.5986 | 61.06 |
| 0.0417 | 1288 | 0.8228 | 2.7086 | 73.26 |
| 0.0893 | 1294 | 0.8115 | 2.6237 | 73.59 |
| 0.1439 | 1307 | 0.8012 | 2.5095 | 73.06 |
| 0.2072 | 1320 | 0.7926 | 2.3580 | 72.41 |
| 0.2817 | 1333 | 0.78296 | 2.2553 | 71.88 |
| 0.3703 | 1346 | 0.7731 | 2.0097 | 71.40 |
| 0.4778 | 1359 | 0.7638 | 1.9784 | 70.89 |
| 0.6107 | 1372 | 0.7548 | 1.8156 | 70.38 |
| 0.7792 | 1385 | 0.7448 | 1.6298 | 69.99 |
| 1.0000 | 1397 | 0.7334 | 1.2521 | 69.87 |

**Table-4:- Value of $V_f$, $L_f$, Z, and τ at $308^0$K for diethyl ether and malathion binary liquid mixture**

| Free Volume ($V_f$) x $10^7$/m$^3$.mol$^{-1}$ | Intermolecular Free Length ($L_f$) x $10^{11}$/m | Specific impedance (C.G.S.) | Shear's relaxation time (τ) x $10^{-9}$sec. |
|---|---|---|---|
| 66.78 | 0.4973 | 1.2816 | 1.3014 |
| 36.89 | 0.5447 | 1.0598 | 2.6458 |
| 46.76 | 0.5460 | 1.0501 | 2.5745 |
| 60.76 | 0.5440 | 1.0472 | 2.4448 |
| 81.03 | 0.5396 | 1.0462 | 2.2766 |
| 105.26 | 0.5378 | 1.0436 | 2.1616 |
| 142.63 | 0.5359 | 1.0406 | 1.9988 |
| 190.41 | 0.5339 | 1.0380 | 1.8700 |
| 265.73 | 0.5325 | 1.0356 | 1.7038 |
| 385.82 | 0.5320 | 1.0315 | 1.5210 |
| 712.94 | 0.5315 | 1.0246 | 1.1664 |

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