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# Acoustic study of ethanolic binary mixture of natural sap of phoenix sylvestris at different temperature

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## Abstract

*Various thermodynamic properties of solid and liquid can be determined by measurement of ultrasonic velocity. Properties of liquid may vary with the variation in temperature and concentration of solution. Present experimental study has been performed at three different temperatures to measure the longitudinal sound velocity by means of ultrasonic interferometer. Binary solutions of different concentration were prepared by mixing sap of Phoenix sylvestris in pure ethanol (99.9% AR grade). In the sequal acoustic parameters including acoustic impedance (Z), adiabatic compressibility ($\beta_a$), Intermolecular free length ($L_f$ ) and bulk modulus (K) have been derived by using sound velocity. Sound velocity has been measured at a constant frequency 2MHz and at different temperatures. Trends of variation of speed of sound and the variations of these parameters are discussed in terms of different intermolecular interaction.*

**Keywords:** Ultrasonic velocity, Binary mixture, Molecular interaction, Phoenix sylvestris.

## Introduction

Date Palm tree has total 14 species in the world which is a member of the Arecaceae family. It is found in abundance in topsy-turvy land near the lake, river and water resources in India. Date palm tree is also known by various names such as Indian date palm, sugar date palm, wild date palm, khajur, khajuri etc. One of these species is Phoenix Sylvestris (PS). Although the growth rate is very slow but PS[1] is a multipurpose tree. Fruits are generally sweet, comes in May-June. These are used as food as well as fodder for the animals. Leaf crown is cut and widely used to prepare baskets, mats, fans and broomsticks in India. The stem is cylindrical in Shape and relatively tall. No branching of stem but unusual case of multi branching also observed in India. The stem of the palm tree is used as a supporting beam in houses. The half shell is sometimes used as a pipe to rotate water in cannels. The engineering and industrial aspects are much more because of multipurpose features of its every part. PS is an indigenous tree. Sap[2] of PS is taped early in the morning and drink as healthy beverage. Usually people say that if the sap is taken with empty stomach it help to improve digestive system. Research has also approved this fact. The roots are used to examine anti-ulcer activity[3] result are favorable of the study to cure gastric ulcer. In Ayurveda and Pharmacology[4] PS is used to treat toothache, urinary disorder, digestive disorders and anti inflammatory activities[5]. PS is also rich in nutritional value[6]. In Most chemical processes, mixed solvents are used rather than pure solvents which find many practical application and their properties are less known. Measured values of density, ultrasonic velocity are important to understand behavior of molecular interaction in liquid mixture for engineering and industrial purpose. There are the three techniques which are the generally used for the measurement of ultrasonic velocity viz. optical diffraction technique, echo pulse technique and interferometric technique[7]. In our study, interferometric technique has been used to measure ultrasonic velocity at different temperature but at constant frequency.

## Materials and methods

The sap of phoenix sylvestries was collected early in the morning at Fulgavadi near Dhar district, MP, India. It is readily and spontaneously fermented resulting in the development of alcoholic fermentation products. The fresh taped sap was kept in thermostat to reduce fermentation rate. Binary mixture was prepared by mixing pure natural sap of phoenix sylvestries "PS" and pure Ethanol (99.9%, AR grad) in different concentration.

**Density Measurement:** Density of sample was measured by using specific gravity bottle by following relation -

$\rho = m/v$

**Ultrasonic velocity measurement:** Nanofluide interferometer of Mittal Enterprises, New Delhi, India (Model NF-10X) is used to measure ultrasonic velocity in prepared sample at fixed

frequency 2MHz[8]. USV is evaluated by using the following relation -

Velocity = wavelength × frequency
$U = \lambda \times f$

**Temperature controller:** To study variation in ultrasonic velocity at different temperature, a temperature controller water bath from Mittal enterprises is used to maintain constant temperature. Hot water is flown through the two nipples provided in double walled jacket of the cell for circulate around the experiment liquid and desired temperature was achieved.

**Theory:** The experiment was performed at fixed frequency 2MHz. various acoustic[9-11] parameters namely acoustic impedance Z, adiabatic compressibility βa, intermolecular free length $L_f$ and bulk modulus (K) were measured using standard relation.

$$Z = \rho U \quad (1)$$

$$\beta_a = 1/U^2\rho \quad (2)$$

$$L_f = k/U\rho^{1/2} \quad (3)$$

Where: k is Jacobson's constant which depends on temperature and is given by relation $k = (93.875+0.375T) \times 10^{-8}$. Where: T is the absolute temperature.

$$K=U^2\rho \quad (4)$$

## Results and discussion

The tentative value of ρ and U, calculated values of Z, βa, $L_f$, and K as function of concentration for pure PS and Ethanol at three different temperatures is significant to understand molecular interaction of binary liquid mixtures.

It is to be noted that the temperature plays a vital role in studying the different ultrasonic parameters in different combination of binary mixtures at constant frequency. Increasing ultrasonic velocity with increasing concentration of sap of PS in liquid mixtures gives an idea that the system is becoming more compact which leads lesser compressibility and hence sound velocity increases. It may be attributed due to large difference in molar volume which allows them pack well into each other's structure.

From Table-1 it is prominent that the ultrasonic velocity drops with rise in temperature. It shows a decrease in intermolecular force[12] due to the increase in the thermal energy of the system. From Table-1 the data reveals that both the ultrasonic velocity and Density of liquid mixture increases with increase in concentration of PS sap in ethanol for all three temperatures. It is occurred because of presence of "PS" which makes the solution thicker while it decreases with increase in temperature in all samples as shown in Figure-1 and 2. Acoustic impedance of mixture increases with increase in concentration of "PS" sap whereas at different temperature it decreases for particular mixture as the temperature increases.

There is fall of intermolecular free length and adiabatic compressibility with increase in concentration of PS sap. Lower the compressibility is a sign of maximum interaction.

The gradual decreases in adiabatic compressibility with sap of PS suggest that the medium become more and less compressible as shown in Table-2. Whereas increases with increase in temperature, which is quite obvious from variation of sound speed in the system under consideration as $\beta=1/U^2\rho$.

The decreases in β and $L_f$ with concentration imply that the system is in compressed state i.e. the formation of cluster of solute molecules with solvent molecules. The decrease in $L_f$ with concentration offers that the component molecules are closer in the mixture than in pure state.

All fluid has some degree of compressibility. Bulk modulus is a property that indicates the compressibility. It is also a measure of fluid resistance. Ultrasonic velocity in a liquid can produce a compressive force per unit area results the compression of liquid. For all three temperatures bulk modulus increases with concentration of PS in ethanol. As the temperature is increased the distance between the molecules is expected to increase. The resulting decrease in the bulk modulus may be attributed to the consequent decrease in the intermolecular potential.

**Table-1:** Variation of ultrasonic velocity, density and acoustic impedance in prepared sample at three different temperatures.

| T (K) | Ultrasonic Velocity U (m/s) | | | | | Density $\rho\times10^3$ ( kg/m$^3$) | | | | | Acoustic Impedance $Z\times10^6$ (kg m$^{-2}$ s$^{-1}$ ) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S-1 | S-2 | S-3 | S-4 | S-5 | S-1 | S-2 | S-3 | S-4 | S-5 | S-1 | S-2 | S-3 | S-4 | S-5 |
| 301.7 | 1135.36 | 1337.41 | 1492.01 | 1627.36 | 1544.81 | 0.778 | 0.874 | 0.952 | 1.015 | 1.148 | 0.883 | 1.168 | 1.420 | 1.651 | 1.773 |
| 306.7 | 1117.4 | 1324 | 1489.88 | 1620.4 | 1540.08 | 0.773 | 0.871 | 0.947 | 1.006 | 1.147 | 0.863 | 1.153 | 1.410 | 1.630 | 1.766 |
| 311.7 | 1100.7 | 1313.68 | 1487.25 | 1610.42 | 1537.42 | 0.769 | 0.870 | 0.945 | 1.002 | 1.145 | 0.846 | 1.145 | 1.405 | 1.623 | 1.760 |

**Table-2:** Variation of adiabatic compressibility, intermolecular free length and bulk modulus of prepared liquid at three different temperatures.

| T (K) | Adiabatic compressibility $\beta a \times 10^{-10}$ ($Pa^{-1}$) | | | | | Intermolecular Free Length $L_f$ (Å) | | | | | Bulk Modulus $K \times 10^9$ ($Nm^{-2}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S-1 | S-2 | S-3 | S-4 | S-5 | S-1 | S-2 | S-3 | S-4 | S-5 | S-1 | S-2 | S-3 | S-4 | S-5 |
| 301.7 | 9.971 | 6.397 | 4.719 | 3.720 | 3.650 | 0.656 | 0.524 | 0.450 | 0.399 | 0.395 | 1.002 | 1.563 | 2.119 | 2.688 | 2.741 |
| 306.7 | 10.361 | 6.549 | 4.757 | 3.786 | 3.675 | 0.672 | 0.535 | 0.456 | 0.406 | 0.401 | 0.965 | 1.526 | 2.102 | 2.641 | 2.721 |
| 311.7 | 10.733 | 6.645 | 4.784 | 3.856 | 3.694 | 0.690 | 0.544 | 0.461 | 0.413 | 0.405 | 0.932 | 1.504 | 2.089 | 2.614 | 2.706 |

Graph plotted from experimental values for ultrasonic velocity and density v/s concentration for different temperatures.

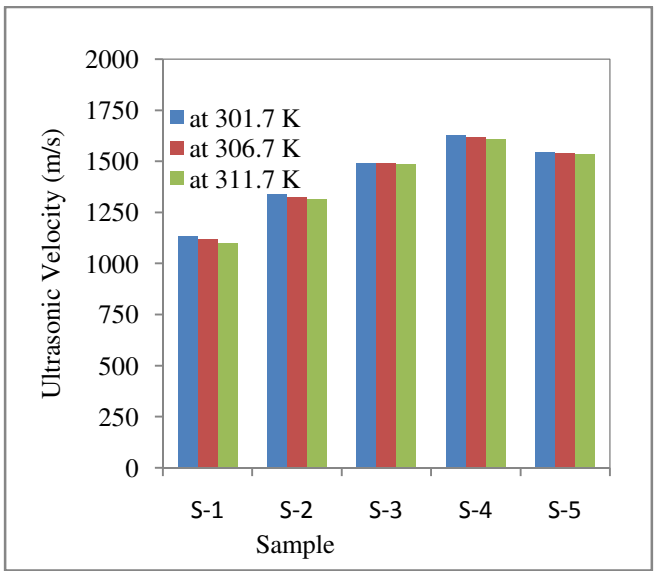


**Figure-1:** Ultrasonic Velocity v/s Concentration.

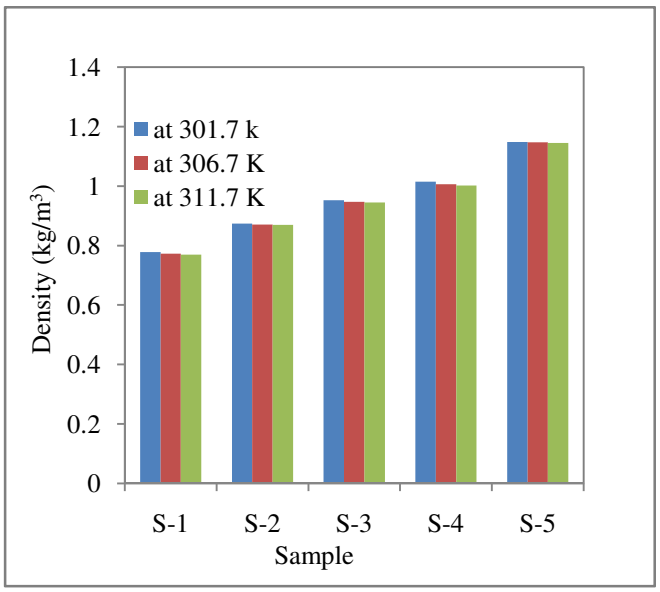


**Figure-2:** Density v/s Concentration.

## Conclusion

In the present study ultrasonic velocity, density, acoustic impedance, adiabatic compressibility, intermolecular free length and bulk modulus of binary mixture of ethanol and PS sap determined as function of composition at three different temperatures. In Namoto theory, it is supposed that the volume does not change on mixing[13]. All parameter of study indicates the presence of molecular interaction between the component molecules. Figure-1 shows the higher ultrasonic velocity in some intermediate concentration range suggest the existence of strong tendency for the association between the component molecules, where hydrogen bonding may be formed[14].

**Table-3:** Abraviation table for various prepared sample

| S.N. | Sample composition | Abraviation |
|---|---|---|
| 1. | Pure ethanol (99.9%) | S-1 |
| 2. | 75% Pure ethanol +25% PS sap | S-2 |
| 3. | 50% Pure ethanol +50% PS sap | S-3 |
| 4. | 25% Pure ethanol +75% PS sap | S-4 |
| 5. | Pure PS sap | S-5 |

## References

1. Theodore Cooke C.I.E. (1903). Flora of the presidency of Bombay. London: Taylor and Francis, 1, 502-504.
2. Chandrashekhar K., Sreevani S., Sheshapani P. and Pramodhakumari J. (2012). A Review on palm wine. *International J. of research in biological sciences*, 2(1), 33-38.
3. Gandhimathi R. and Sreedevi A. (2012). Evaluation of Ethanolic extract of anti-ulcerogenic activities of Phoenix sylvestrisRoxb. *International Jour. of Medical chemistry & Analysis*, 2(1), 6-11.
4. PandiSelvi A. and Rajkumar S. (2012). Evaluation of acute and chronic toxicity studies of Phoenix SylvestrisRoxb in

experimental animal. *International Jour. Of Exp. Pharmacology*, 2(1), 32-36.

**5.** Mukharjee K., Paul D.P. and Banerjee E. (2014). Anti inflammatory Activities of Date palm extracts. Antioxidants, 3, 1-21, ISSN 2076-3921.

**6.** Salvi J. and Katewa S.S. (2014). Preliminary assessment of nutritional value of palm heart of Phoenix sylvestris Rox b. *International food research J*., 21(5), 2051-2054.

**7.** Chimankar O.P. and Pawar N.R. (2014). Ultrasonic investigation of bio-liquid mixture of methanol with cinnamaldhyde by interferometric method operated in the frequency range 1M Hz-10MHz. *International Journal of Research in Engineering and Technology*, 3(6), 315-324.

**8.** Phadke S., Shrivastava B.D. and Mishra A. (2009). Roll of frequency in studying intermolecular interaction in binary liquid mixture of Borassus Flebllifier and Ethanol. National conference at VIT university, Vellore(T.N.), 978-981.

**9.** Phadke S., Shrivastava B.D. and Mishra A. (2011). Acoustical parameter of aqueous solution of Borassus Flablifier Fruit pulp by non destructive method. *Jour. of Trans tech Publication*, Defect and Diffusion Forum, 312, 358-363.

**10.** Chouhan M.S., Chouhan R.S., Patil B.R., Modi K., Shrivastava B.D., Phadke S. and Patil S. (2016). Ultrasonic investigation of Aloe Vera juice, Water, ethanol, n-Butanol and acetic acid at 298K temperature and 2MHz frequency by NDT. *International J. of applied Research*, 2(8), 301-304.

**11.** Ujle S.K., Phadke S., Shrivastava B.D., Mishra A. and Dagaonkar N. (2013). Acoustic Studies of Aqueous Solution of Adansonia Digitata (AnD). *Research Journal of Physical Sciences*,1(4), 32-35.

**12.** Singh I., Shakya N. and Yadav S.S. (2012). Investigation of type of interaction between salicylic Acid and ethanol at different temperature. *International Journal of Chemical, Environmental and Pharmaceutical Research*, 3(2), 127-129.

**13.** Tumberphale U.B., Kawale R.S., Pawar N.P. and Kalamse G.M. (2015). Ultrasonic behavior of binary mixture of ethanol in ethyline diamin at 3MHz frequency. *International Symposium on Ultrasonics*, 22(24), 343-346.

**14.** Rao G.V., Sarma A. Viswanatha, J. Krishna and C. Rambabu (2005). Theoritical evaluation of ultrasonic velocity in binary liquid mixture of o-chlorophenol at different temperatures. *Indian journal of pure and applied physics*, 43, 345-354.